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SWINE RESEARCH

of the

United States Department of Agriculture  
and Cooperating Agencies + 3 a

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

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UNITED STATES DEPARTMENT OF AGRICULTURE5 a  
Washington, D. C.

December 1, 1963

## ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research and Service
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton and Tobacco Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research

## ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

### Agricultural Research Service (ARS)

- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite

### Agricultural Marketing Service (AMS)

- 4 - Market Quality
- 4 - Transportation and Facilities

### Economic Research Service (ERS)

- 4,5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Resource Development Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

### Other Services

- 1 - Soil Conservation Service (SCS)
- 4,5 - Farmer Cooperative Service (FCS)
- 4,5 - Statistical Reporting Service (SRS)
- 6 - Forest Service (FS)



Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering  
Crops  
Entomology

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

- |  |  |
|--|--|
| 1 - Cross Commodity Research of<br>Agricultural Engineering, Crops,<br>& Entomology Research Divisions | 8 - Cotton and Cottonseed<br>8 - Tobacco |
| 3 - Rural Dwellings  | 9 - Grain and Forage Crops               |
| 6 - Forestry (Other than Forest<br>Service)  | 10 - Citrus and Subtropical Fruit        |
| 7 - Beef Cattle  | 10 - Deciduous Fruit & Tree Nut          |
| 7 - Dairy  | 10 - Potato                              |
| 7 - Poultry  | 10 - Vegetable                           |
| 7 - Sheep and Wool   | 10 - Florist, Nursery & Shade Tree       |
| 7 - Swine  | 11 - Oilseed and Peanut                  |
| 7 - Cross-Specie & Miscellaneous<br>Animal Research  | 11 - Sugar                               |

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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## INTRODUCTION

This report on swine research covers work directly related to the production, processing, distribution, and consumption of pork. The information has been assembled from the organizational unit reports of the several divisions. This report does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only swine problems but also to the problems of other commodities. Progress on cross-commodity work is found in the reports of the several divisions such as Soil and Water Conservation, Human Nutrition, Transportation and Facilities, Farm Production Economics, Foreign Development and Trade Analysis, and Cross-Specie and Miscellaneous Animal Research.

This report is devoted to the 13 "problem areas" shown in the table of contents. For each area there is a statement of (1) the Problem, (2) the USDA Program, (3) A summary of Progress during the past year on USDA and cooperative work, and (4) A list of Publications resulting from USDA and cooperative work.

Swine research can be divided into three major categories, i.e., that supported by (1) Federal funds appropriated to the research agencies of the United States Department of Agriculture, (2) Federal and State funds appropriated to the 53 State Agricultural Experiment Stations, and (3) private funds allotted, largely by the swine industry, to research carried on in private laboratories or to support of State Station or USDA work. For all three categories it is estimated that about 800 scientists are engaged in research dealing specifically with the production, processing, distribution, and consumption of pork. Support of their work involves an annual expenditure of between 20 and 25 million dollars. This amounts to about 0.6% of the cash farm receipts from hogs and about 0.3% of the retail value of pork products. Of the 800 scientists engaged in swine research, approximately 14% are employed by the Department of Agriculture, 20% by the State Experiment Stations, and 66% by other universities, foundations, and private industry.

### Research by USDA

Farm research pertaining to swine is conducted in the Agricultural Research Service divisions of Agricultural Engineering, Animal Disease and Parasite, Animal Husbandry, and Entomology. The work comprises investigations of breeding, physiology, nutrition, diseases and parasites, housing equipment, management and production influences on animal products. The work involves 79 professional man-years of scientific effort.



Nutrition, consumer, and industrial use research pertaining to pork is conducted in the Agricultural Research Service divisions of Human Nutrition, Consumer and Food Economics, and Western Utilization. The work comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions; and with the processing phase involving slaughter, cutting, trimming, smoking, curing, and preparing for later use by consumers. The work includes considerable emphasis on chemical and physical properties of meat. Also, it is concerned with improved equipment and processes. The work in these divisions involves 25 professional man-years of scientific effort.

Marketing and economic research pertaining to live animals and pork is carried on within four Services: Agricultural Marketing Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing, and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, AMS; Transportation and Facilities, AMS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Marketing Division, FCS; Standards and Research, SRS'. The scientific effort involved by these divisions amounts to 12 professional man-years.

#### Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects swine research is carried in 47 of the 53 State Experiment Stations. The types of work to which the largest amount of effort is devoted include breeding, physiology, nutrition and management, diseases and parasites, marketing and economics, and utilization research on meats and animal fats. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Privately supported swine research emphasizes the solution of scientific production, processing, and marketing problems. Much of it utilizes the results of basic work done by State Station and Department scientists.



About one-third of industry's contribution to the research effort pertains to farm research. In contrast with the poultry industry where practically all breeding research is done by industry, very little is done by industry in beef, except the work of large firms like the King Ranch which developed the Santa Gertrudis breed. In the case of swine there is a real opportunity for increased participation by industry. The task of evaluating breeds, the performance of breeds in crossing, and the comparison of crossing systems will take more animals than are available at publicly supported experiment stations.

About equal to the farm research effort in the livestock industry, another one-third is in the utilization field. In contrast with the public research in basic work the industry program places strong emphasis on developmental activities and solving of immediate problems. The work of meatpackers is devoted to finding industrial utilization of by-products, quality control devices, improved formulation of products, improved handling and plant arrangement. Independent laboratories and foundations take on short time problem-solving for clients in the meat industry. Pharmaceutical firms carry on research on extraction of biologically active substances from meat by-products such as hormones from glands, and with the development of agents, such as antibiotics for use in meat processing.

The contributions of swine producers and industry to the work of the State Stations and the Department have been an important factor in the success of their research programs. Producers offer herds and facilities for testing products and practices used in production. Likewise, processors and retailers offer facilities and products for use by public research agencies. Many problems in the economics of marketing cannot be transferred to a laboratory, experimental plot, or other simulated situation. The results of economic research conducted cooperatively is of great value to industry, especially in cases where public research can provide comparison and analysis. Even large firms that have a research staff do not have access to the plants and records of competitors.

#### Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Ventilation of livestock buildings. Research in cooperation with State Experiment Stations has obtained much needed basic data on the heat and moisture given off by cattle, hogs, and poultry, and on the influence of building environment on production and feed consumption. The heat and moisture dissipation data are considered basic design data for ventilation systems of poultry, dairy, and swine buildings. They appear in design handbooks including the 1962 Guide and Data Book of the American Society of Heating, Refrigeration, Ventilating, and Air

Conditioning Engineers, and are used by makers of ventilating equipment, prefabricated buildings and package buildings as well as by specialists advising farmers on their own construction. Building improvements resulting from the above research have contributed to the substantial rise in efficiency of livestock production that has occurred during the past decade.

"Break-through" on iron-deficiency anemia confirmed. In trace mineral studies at Beltsville on young pigs, three oral preparations containing iron were tested for effectiveness of claimed protection of baby pigs from iron-deficiency anemia by increasing the iron content of sow's milk. Two of these preparations were found to be ineffective. The third compound gave satisfactory protection to baby pigs which suckled iron supplemented dams. These results confirmed similar findings at the Kentucky, Louisiana, and Iowa Experiment Stations. This represents an important "break-through" in situations where iron therapy has had to be given directly to baby pigs.

Emulsifying capacity of meat. A simple technique has been devised by EU scientists to rapidly determine the emulsifying capacity of meat from different sources used in sausage formulations. "Emulsifying capacity" is an important property of meat utilized in manufacture of frankfurters, bologna and other emulsion-cured meat products. This development has facilitated the application of automatic data processing to accurate sausage formulation by providing quantitative measurements of the fat-binding potential of the meat. Use of this technique is proving advantageous to sausage manufacturers from the standpoint of cost and overall product quality.

Central preparation of meat for retail sale. Exploratory research conducted in small central meat packaging plants indicates that the yearly facility, equipment, and labor costs of processing and packaging meat for retail sales can be reduced as much as 50% in plants with \$250,000 weekly meat volume. This represents a saving equal to 4.6% of retail sales. These findings make a number of assumptions that need to be tested further.



SWINE - BREEDING  
Animal Husbandry Research Division, ARS

Problem. Improvements in the heredity of swine depend on the intensity and accuracy of selection practiced in choosing breeding animals and on the choice of a mating system that maximizes the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that over 90% of the pigs marketed in the United States are currently some kind of crossbreds. Research in swine breeding thus is faced with the dual challenge of developing foundation seed stock populations that yield maximum improvement for commercial production and also devising methods that fully utilize the genetic potential of available seed stocks for further increases from heterosis and hybrid vigor generally shown by crossbred pigs. It is essential that experimental work continue the development of genetic facts and practical methods that breeders can use to develop better and more efficient seed stock strains. Particular effort is needed on effective genetic means for efficient production of pork with more lean and less fat without sacrificing gains in other production traits.

USDA PROGRAM

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. It is a coordinated research effort between several State Agricultural Experiment Stations and the USDA. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate, feed efficiency, carcass composition, and quality of meat.

A cooperative project with the Food and Drug Administration was started in 1963 to investigate the response of a herd of miniature swine to further reduction in body size from selection and the usefulness of this strain of swine for toxological tests as well as basic studies in nutrition and genetics.

The Federal scientific effort in this area totals 9.5 professional man-years. Of this number, 0.0 is devoted to genetics and interrelations of performance traits, 7.4 to selection and breeding systems, and 2.1 to program leadership.



A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years, 1962-1966, and involves PL-480 funds.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Genetics and Interrelations of Performance Traits

1. Genetic and phenotypic parameters. A study involving 3,871 litter records collected at three stations during the period 1944 to 1958 showed that approximately 15% of the total variances in litter size at birth and at weaning and about 30% of the variance in litter weight at weaning could be ascribed to the combined effects of differences between stations, breeds, years, seasons, farrowing history, age and inbreeding of sow, and inbreeding of litter. Heritabilities based on daughter-dam regressions of data corrected for the various environmental effects considered in the analysis were estimated at  $.08 \pm .04$  for litter size at birth,  $.07 \pm .04$  for litter size at one day of age,  $.14 \pm .04$  for litter size at 56 days,  $.22 \pm .04$  for litter weight at 56 days, and  $.09 \pm .04$  for litter size at 154 days. Repeatabilities estimated from intraclass correlations of records from the same sow were lower for three of the five traits than the corresponding heritabilities. These results suggest compensatory carryover effects tending to make successive litters out of the same sow more unlike than they would have been otherwise. It was also found that daughters from litters of one to five pigs had litters which were, on the average, larger than those of daughters from litters of six to ten pigs. (AH al-4)

At the Iowa Station, data from 271 test groups fed under Record-of-Performance conditions on one farm and data from 248 litters raised in an irradiation experiment on another farm were analyzed (1) to evaluate the effects of certain environmental factors on growth rate and feed efficiency, (2) to obtain estimates of heritability and genetic and phenotypic correlations for these traits, and (3) to study the effect of paternal irradiation. About half of the boars in the irradiation experiment were treated locally at the testicle with 300 r. X-irradiation at about six months of age. Heritabilities based on the variance between litter means were estimated at .22 and .55 for daily gain, at .54 for 154-day weight, and at .52 and .38 for feed efficiency. Genetic correlations obtained for daily gain with feed requirements were  $-.643$  and  $-.555$ . Corresponding phenotypic correlations were  $-.541$  and  $-.085$ . Intraclass correlations between paternal half-sib litters from irradiated sires were smaller for all traits than those from control sires. The respective correlations were .183 and .320 for daily gain, .184 and .304 for 154-day weight, and .115 and .206 for feed efficiency. (AH al-4)

Heritabilities obtained by the paternal half-sib method from data collected on 1,715 pigs belonging to the miniature herd at the Hormel Institute, Austin, Minnesota, were  $.53 \pm .36$  for 56-day weight,  $.43 \pm .36$  for 112-day

weight,  $.45 \pm .38$  for 154-day weight, and  $.46 \pm .34$  for daily gain from 56 to 154 days of age. Pooled estimates obtained by paternal half-sib correlations and two methods of offspring-parent regression were considerably smaller; i.e.,  $.08 \pm .059$  for 56-day weight,  $.16 \pm .066$  for 154-day weight, and  $.15 \pm .059$  for daily gain. (AH al-17)

Genetic correlations obtained for weaning weight with post-weaning growth rate at the Minnesota Station were  $.58 \pm .30$  from an analysis of variance and covariance,  $.62$  from regression of offspring on sire, and  $.92$  from intrasire regression of offspring on dam. Heritability estimates were  $.14 \pm .11$ ,  $.07 \pm .06$ , and  $.26 \pm .07$ , respectively, for weaning weight, and  $.26 \pm .10$ ,  $.15 \pm .11$ , and  $.34 \pm .69$  for daily gain. The corresponding pooled heritabilities were  $.18$  and  $.31$ , while the pooled genetic and phenotypic correlations among the two traits were  $.69$  and  $.37$ , respectively. Data on 2,693 pigs from 357 gilt litters by 129 sires of the Minnesota No. 2 and No. 3 breeds were available for the above study. (AH al-17)

In another study at Minnesota, data from 56 sires with both purebred and crossbred progeny were used to estimate the covariance of sire effects in purebred and crossbred populations of the Minnesota breeds of swine. Estimates were  $-2.42 \pm 3.67$  for weaning weight,  $.0040 \pm .0018$  for daily gain, and  $.0005 \pm .0007$  for backfat probe. These findings indicate that if mass selections were practiced in both sexes of both purebred populations that make up a cross, crossbreds produced by animals thus selected would show a 17% decrease of the amount reached for when selecting for weaning weight, and a 42% and 7% increase of the amount reached for when selecting for daily gain and backfat probe, respectively. (AH al-17)

At the Oklahoma Station, data on 11,876 pigs from two experimental herds at that Station and data on 6,828 pigs from one herd in Iowa were studied to estimate the relative importance of different causes of variation in nipple number. The average number of nipples per side was 6.22 and the standard deviation was .71. Sex, litter size, and parity of dam were found to have little influence on nipple number. There was evidence of breed differences, but no indication of influence from inbreeding or heterosis. The average difference in nipple number between the right and left side was small and indicated that the observed asymmetry was more or less random for each pig. About 28% of the variance of nipple number per side was attributable to additive gene action, 3% to genetic differences in maternal influence, 10% to environmental factors affecting both sides of the same pig alike, and about 59% to environmental factors affecting the two sides of the same pig differently. At the Missouri Station, heritability of nipple number was estimated at  $.46$ . Sex of the pig was not important and there was no evidence of maternal influence when reciprocal crosses were compared. (AH al-6 and al-8)

A study of sexual maturity as measured by age at first estrus for 180 gilts in a breeding experiment at Beltsville showed crossbred gilts averaging about 17 days younger and about 16 pounds heavier at puberty than contemporary straightbred gilts in two strains derived from the same sources as



those used to produce the crosses. The averages for age at first heat for LL, BB, BL, and LB gilts were 212, 206, 196, and 189 days, respectively. The pooled standard deviation within group was 30 days. Straightbreds and crossbreds produced by the two groups of straightbred dams showed an average difference of about six days in age at puberty, indicating that genetic differences in maternal effects may be responsible for some of the variations found in age at first heat. The fractions of variance accounted for by the combined effects of age at first heat, weight at first heat, and number of days from age at first heat to conception varied from about 3% to 33% for litter size at birth and from about 10% to 22% for litter weight at birth. These results emphasize the need for more information about the factors primarily responsible for the variation in age of gilts at puberty and in their subsequent productivity as dams. (AH al-13)

An analysis of data from a selection experiment for high and low fatness in Duroc and Yorkshire swine at Beltsville indicates that inbreeding effects on backfat thickness and post-weaning growth rate may vary with the direction in which selection is practiced and be influenced by the genetic makeup of the particular stock from which selected lines are being developed. In the Duroc breed, inbreeding decreased the rate of fat deposition in the high-fat line and increased it in the low-fat line, whereas for the high- and low-fat Yorkshire lines the reverse situation was observed. Selection for high and low fatness also showed a differential inbreeding effect on daily gain for direction of selection pressure which was similar for both breeds. Both backfat thickness and daily gain tended to decrease with inbreeding in the unselected Duroc and Yorkshire control lines. Partial regression coefficients on date born showed earlier born pigs in the three Duroc lines averaging fatter and slower growing than pigs born later in the season, whereas in the three Yorkshire lines the reverse situation was found for both traits. In both breeds, heavier pigs at weaning averaged lower in backfat thickness and grew faster after weaning than the lighter ones. These results for post-weaning growth rate are in agreement with results reported by other workers. (AH al-12)

2. Pilot experiments. Genetic correlations between litter size and growth rate in mice were studied at the Minnesota Station. Estimates of genetic parameters were  $0.306 \pm 0.097$  for the additive genetic variance of growth rate,  $0.29 \pm 0.107$  for the additive genetic variance of litter size, and  $0.046 \pm 0.229$  for the additive genetic covariance between litter size and growth rate. The heritability of litter size was  $0.11 \pm 0.041$  and of growth rate  $0.214 \pm 0.068$ . The estimate of 0.153 for the genetic correlation between the two traits was not significantly different from zero. The results suggest that correlated response, if any, will be in the direction of larger litters. The actual genetic change in average litter size during 13 generations of selection was  $0.082 \pm 0.035$  mice per generation in terms of linear regression. (AH al-17)

In another study at the Minnesota Station, selection for post-weaning growth rate in mice has continued to be effective through the 19th generation. No



significant deviation from linearity has been found in the regression of response to selection on generation time. Improvement in the cross of the selected population with the unselected control has been about one-half that of the selected population. This is to be expected if genes are largely additive in their effect. Estimates of the genetic correlation between growth and litter size have been positive. In agreement with this, litter size has increased in the population selected for growth by about 1.6 mice per litter. (AH al-17)

## B. Selection and Breeding Systems

1. Selection for single traits. Selection based on backfat thickness has been carried through eight generations in the high- and low-fat Duroc lines and through six generations in the high- and low-fat Yorkshire lines. Backfat thickness at 175 pounds averaged 2.03, 1.20, and 1.56 inches for eighth generation high-fat, low-fat, and control line Duroc pigs, and 1.43, 1.12, and 1.30 inches for sixth generation high-fat, low-fat, and control line Yorkshire pigs. The means for the selected lines differ only slightly from their respective means in 1961. However, in each case the differences pointed in the direction in which selection was practiced, with the control line in each breed averaging slightly higher in 1962 than in 1961. In Durocs, post-weaning daily gain continued to average somewhat higher in the control line than in the selected lines, the respective averages for high-, low-, and control line pigs being 1.46, 1.40, and 1.49 pounds. Daily gain for the three Yorkshire lines averaged 1.25, 1.21, and 1.30 pounds, respectively.

Averages based on eight years' data for the Duroc lines and on six years' data for the Yorkshire lines show that in the Duroc breed the low-fat line was equal or superior to the high-fat line in all traits studied. The control line in turn excelled the two selected lines in conception rate, in litter size, and in litter weight at birth and at weaning, and was intermediate with respect to percent stillborn pigs and pig weight at birth and at weaning. While dam's weight at breeding differed little between lines, high-fat gilts gained about 41 pounds less weight during the gestation period than low-fat gilts with control line gilts intermediate between the two selected lines. During the suckling period, high-fat gilts continued to put on weight at the rate of about .38 pound daily, compared with .07 pound gain for low-fat gilts and a .14 pound loss for control line gilts. Thus, it appears that in Durocs selection for high fatness has tended to modify the growth pattern with the result that high-fat animals average lower in mature body weight than those in the low-fat control lines. Thus far, selection in the Yorkshire breed appears to have had little or no effect on preweaning growth rate or mature body weight. The three Yorkshire lines also have differed only slightly with respect to litter size, litter weight, and pig weight at birth and at weaning. Conception rates, on the other hand, averaged about 10% less in low-fat than in high-fat or control line gilts.

Carcass data obtained on samples of pigs continued to show rather marked differences between high- and low-fat pigs, with controls generally intermediate between the selected lines in both breeds. Eighth generation high-fat, low-fat, and control line Durocs averaged 2.43, 1.41, and 2.06 inches in backfat thickness; 27.8, 30.1, and 28.8 inches in length of carcass; 2.73, 3.99, and 3.24 square inches in loin eye muscle area; 35.4, 40.8, and 37.8% in yield of lean cuts; 19.6, 13.2, and 16.7% in yield of fat cuts; and 11.7, 9.7, and 10.6% in yield of bacon. Sixth generation high-, low-, and control line Yorkshire pigs averaged 1.90, 1.28, and 1.26 inches in backfat thickness; 30.9, 31.0, and 31.1 inches in length of carcass; 3.30, 4.28, and 3.47 square inches in loin eye muscle area; 38.2, 41.2, and 39.3% in yield of lean cuts; 15.7, 12.6, and 14.7% in yield of fat cuts; and 11.2, 10.0, and 10.5% in yield of bacon.

Generation means obtained for the three Duroc and three Yorkshire lines after adjusting each individual record to zero inbreeding, average weaning weight, and average day of year born of respective control line pigs as well as for sex effects to the average of boars, barrows, and gilts showed that transformation of the original backfat measurements to logarithms did not remove any of the asymmetry in the responses of backfat thickness shown by the high- and low-fat Duroc pigs. Thus, the relatively greater effectiveness of selection for high than for low fatness in Durocs can hardly be attributed to the existence of genes with multiplicative effects on backfat thickness. (AH al-12)

At the Missouri Station, three generations of selection for low backfat thickness in Polands have been completed with replications in the spring and fall. Boars and gilts in the spring line now have .08 and .16 inches less backfat than the foundation animals. In the fall line, backfat thickness has been reduced by .16 and .24 inches. There has been a decline in daily gain in both lines even though animals selected for breeding were above the average of the group from which they were selected. Data on ovulation rate and embryonic death loss in gilts bred and slaughtered and in gilts farrowing and weaning litters suggested that the genetically leaner gilts farrowed and weaned larger and heavier litters than the fatter ones. (AH al-6)

Selection for low backfat thickness was continued at the South Dakota Station with a line of Duroc pigs. Although parents of 1962 pigs averaged .17 inches less fat than the group from which they were selected, no reduction was noted in average backfat between the 1961 and 1962 pig crops. (AH al-9 rev. 2)

The effectiveness of selecting for small size at 154 days was studied in the herd of miniature pigs at the Hormel Institute, Austin, Minnesota. Data were available for 1,715 pigs from 640 litters farrowed during the period 1950 to 1958. Selection differentials averaged 9.1 pounds for females and 15.6 for males. Body size decreased at the average rate of



slightly over three pounds per year, compared with an expected decrease of about two pounds. Response to selection for small size has been progressive and constant. (AH al-17)

2. Selection for combining ability. In the Miles City project, litter size at birth averaged the same for single cross as for control strain litters (i.e., 10.0 pigs), but single crosses exceeded controls by 0.8 pig or 10.0% in litter size at weaning, by 108 pounds or 46% in litter weight at weaning, and by 9.2 pounds or 31% in pig weight at weaning. The advantages for crosses in litter size at weaning were of about the same magnitude as those found in the fifth selection cycle, but those in litter weight and pig weight at weaning were considerably larger for sixth than for fifth cycle pigs. Plans in the Miles City project are to test the Montana No. 1 and Yorkshire "Select" strain in crosses with one another as well as in reciprocal crosses with the Montana No. 1 control strain. These crosses are to serve as a basis for evaluating more critically the effectiveness of reciprocal recurrent selection as practiced in this project. (AH al-11)

3. Development and evaluation of inbred lines and crosses. Mainly crossline litters among lines 7, 11, and 14 were produced in 1962 in the rapid inbreeding project at the Michigan Station. Line 11 has been outstanding in fertility as an inbred line of Yorkshires. The foundation dam had 13 litters in 14 seasons. The eight inbred litters averaged 6.8 pigs weaned. The five outbred litters averaged 9.2 pigs. More inbred sows failed to conceive than outbreds. (AH al-14)

The use of close inbreeding for evaluating the performance of and selecting among several samples of the Yorkshire breed has continued at the South Dakota Station. Only three of ten breed samples remain. These have survived two initial generations of close inbreeding, interline crosses, and three more closely inbred generations. Lines are different in conformation as well as performance and carcass traits. Rapid inbreeding among Yorkshire lines has resulted in opportunities for early between-line selection. (AH al-9)

Although inbreeding effects on weaning weight in cattle have been reported to be higher in females than males, an analysis of data from the litters produced from 1956-1963 in the swine breeding project at Michigan indicated that the inbreeding effect on 154-day weight in swine is greater in males than females. Each 10% increase in inbreeding reduced 154-day weight by 8.8 pounds in barrows and 6.4 pounds in gilts. (AH al-14)

4. Environmental influences as related to performance. Pigs from the 1962 spring litters at the Michigan Testing Station gained .10 pounds per day faster, required .31 pounds less feed to make a pound of gain, had .06 inches more backfat, and had .16 square inches smaller loin eyes than fall litters. Sex differences between 30 pairs of full sibs indicated that barrows gained 0.21 pounds faster per day, had 0.12 inches more backfat,



were 0.13 inches shorter, had 0.52 square inches less loin eye area, and had 1.1% less ham and loin than gilts. (AH al-14)

5. Gene pools. The "old" breed gene pool (Line Y) at Lincoln, Nebraska, includes contributions from the following breeds: Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland, Spotted Poland, Tamworth, Welsh, Wessex Saddleback, and Yorkshire. The Large Black and Hereford will be added in 1963. The variation in conformation and color remains high. A second gene pool comprised of the newer breeds of swine will be started in 1964. Breeds to be used include: Beltsville No. 1, Beltsville No. 2, Lacombe, Landrace-Large Black, Maryland No. 1, Montana No. 1, Minnesota Nos. 1, 2, and 3, Palouse, and San Pierre. Small nucleus herds of Duroc, Hampshire, and Yorkshire are maintained to supply breeding stock for nutrition research at the Nebraska Station. Replacements are selected for 140-day weight and backfat thickness. Carcass data from nutrition research will allow a continuing general assessment of the carcass merit in other herds. (AH al-7)

6. Crossbreeding and heterosis. The importance of breed of dam in the production of crossbred hogs was studied at the Missouri Station. Litter size, pig, and litter weight at different ages, backfat probe, body length, and heart girth at 200 pounds were compared in reciprocal crosses of the Landrace X Poland and Duroc breeds and crosses. The crossbred litters from Landrace dams and Poland sires were 0.8, 1.3, and 1.3 pigs larger at birth, 56 days and 154 days, respectively, than in the reciprocal cross. ( $P < .01$ ). Landrace sows produced litters 0.4 pounds lighter at birth, 46.4 pounds heavier at 56 days ( $P < .05$ ), and 170.4 pounds heavier at 154 days ( $P < .005$ ). No significant differences between the reciprocal crosses of these two breeds were found in average fat thickness at shoulder, hip, and ham or in body length and heart girth measurements.

Litter size at birth, 56 days, and 154 days was 2.5, 2.2, and 2.1 pigs larger ( $P < .005$ ) in the L X P sows and Duroc boar cross, than in the reciprocal. Pigs from the L X P sows were also heavier at all ages and in total litter weight. Pigs from Duroc sows had thicker backfat probes at each location (nonsignificant). Pigs from the Duroc sows had shorter bodies ( $P < .005$ ). Significant differences were not found in heart girth. (AH al-6)

Rotation-breed-line crossing of the Hampshire, Duroc, and Yorkshire breeds at South Dakota was continued into the 15th generation. This herd, utilizing boars produced in the lines at Brookings, has been "cleaned-up" through SPF procedures. Second generation pigs were 30% heavier at 56 days and reached market weight three weeks earlier than pigs of the same breeding previously. Thus far, there seems to have been a marked reduction in environmental stress by the SPF process. This suggests an urgent need for more information about the use of SPF animals in studies of swine genetics and the application of results from such herds to usual production methods. (AH al-9)

The effects of heterosis on age at puberty, ovulation rate, and percent embryo survival in gilts bred at a constant sexual age (second estrus) were studied at Nebraska. Yorkshire, Duroc, and reciprocal crossbred gilts from the 1962 spring pig crop were used. The progenies of five Duroc and five Yorkshire sires were represented. Each sire contributed both purebred and X-bred offspring. Age and weight at puberty were both influenced by heterosis. The crossbred gilts were 4.2 days younger and 9.2 pounds heavier at puberty than the purebred gilts ( $P < .05$ ). Sire within breed of sire was also a significant source of variation in age at puberty. The average ages and weights at puberty ranged from 203 to 220 days and 230 to 273 pounds for the Yorkshire sire groups, and from 202 to 226 days and 250 to 256 pounds for the Duroc sire groups. The effect of heterosis on ovulation rate was negligible; the crossbred gilts averaged only .3 more corpora lutea at second estrus than the purebreds. However, breed of sire, sire within breed of sire, and breed of dam were all important sources of variation in ovulation rate. The purebred and crossbred progeny of Yorkshire sires averaged 15.4 corpora lutea at second estrus as compared to 16.8 for similar progeny of the Duroc sires ( $P < .01$ ). The average numbers of corpora lutea ranged from 13.4 to 17.0 for the Yorkshire sire groups, and from 12.9 to 20.8 for the Duroc sire groups ( $P < .01$ ). The progeny of Duroc dams shed one more ovum at second estrus than the progeny of Yorkshire dams, 16.6 vs. 15.6 ( $P = .12$ ). The flushing treatment used stimulated increased ovulation rates in all breeding groups. However, the magnitude of response was closely associated with breed of dam. The purebred and crossbred gilts from Duroc dams showed a response of 2.6 ova to flushing as compared to only a .5 ovum increase in the gilts from Yorkshire dams ( $P < .05$ ). (AH al-7)

### C. Performance and Progeny Testing

Performance and progeny test records on sets of boars from three lines in three different breeds were studied at the Oklahoma Station. The results indicated the usefulness of a herd testing program for the evaluation of individual performance and also of a progeny testing program of selected sires to improve the efficiency of overall selection. Individual performance, pedigree, and family performance are extremely useful in the initial selections of young herd sires. Although these are correlated to the breeding values of these individuals for heritable traits, they are not perfect indicators of breeding value. The progeny test gives new information about breeding value which will make the overall testing and selection program more complete and more reliable. In such a program, it is necessary to test a much larger number of boars than is actually needed for service in order to permit selection on performance test results. Similarly, more boars must be progeny tested than are actually needed for service to permit more opportunity to select on progeny test results and also to increase the chances of locating the really superior sires. (AH al-8)



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SWINE - PHYSIOLOGY  
Animal Husbandry Research Division, ARS

Problem. Continued improvement in efficiency of swine production is dependent on new information regarding the physiology of growth and reproduction as well as environmental adaptation. Particularly in the field of swine fertility, considerable knowledge is needed regarding the development of artificial insemination, including semen and ova preservation and storage. Fertility problems in boars and sows seriously plague the efforts of the industry to produce pork at lowest cost. Development of new genetic aids for improvement of swine requires additional understanding of the physiological processes, particularly those involved in the growth and production of lean meat.

USDA PROGRAM

This is a continuing program conducted by physiologists on basic and applied studies on the physiology of reproduction, artificial insemination, effect of hormones on growth and development, and the physiology of growth and development particularly with respect to the mechanisms involved in fat deposition, muscular development, and inborn metabolic defects. Work in this area at Beltsville has been inactive due to vacancies. This program has been reactivated to develop basic knowledge about swine physiology. Cooperative studies on the physiology of reproduction are included in projects of the Regional Swine Breeding Laboratory at Missouri and Nebraska, with informal preliminary investigations in others when opportunities for them arise.

The Federal scientific effort on research in this area totals 2.4 man-years. Of this number, 0.1 is on physiology of reproduction, 2.0 on physiology of growth and development, and 0.3 on program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Selective fertilization and mating behavior. A comparison of natural mating at the Wisconsin Station with artificial insemination was conducted with sows of various breeds and ages. Fertility three to five days post-mating was used as the criterion of evaluation.

No significant difference in percent conception or percent fertility was noted between groups of sows mated naturally and those bred artificially on the second day of the first post-lactation estrus or on the second day of the second post-lactation estrus. Pooling the results from the naturally bred group with the group bred artificially indicated that conception rate was higher (100.0% vs. 85.4%) and percent fertility was higher

(89.8 vs. 46.3) when sows were bred on the second day of the second post-lactation estrus than when bred on the first day of the second post-lactation estrus.

Sows artificially inseminated on the first day of the first post-lactation estrus had a nonsignificantly higher percent fertility (69.3 vs. 50.5) and conception rate (90.0 vs. 84.2) than when inseminated on the first day of the second post-lactation estrus.

A greater percent of the Duroc sows had cystic follicles and the number of follicular cysts per sow was greater than Yorkshire sows. The frequency in Duroc-Yorkshire crossbreds was intermediate to the two purebred groups. (AH al-10)

2. Factors influencing estrus and fertility. At the Missouri Station, intrauterine migration and embryonic death loss were observed in 119 crossbred gilts slaughtered at the 55th day of pregnancy. Intrauterine migration, determined by comparing the number of embryos in a uterine horn with the number of corpora lutea in the corresponding ovary, was observed in 41.2% of the gilts. The total ovulation rate of both ovaries did not seem related to the occurrence of intrauterine migration. However, an unequal ovulation rate between the ovaries of the same gilts was related to the occurrence of this phenomenon. Migration of the fertilized ova was from the left to the right uterine horn in 69% of the cases. The left ovaries averaged 1.32 more ova than the right. In spite of this unequal production of ova, the embryos were equally divided between the uterine horns at the 55th day of gestation. Where intrauterine migration was observed, litters averaged 1.24 more pigs; and where no intrauterine migration was observed, there were 1.73 fewer corpora lutea not represented by embryos. This suggests the possibility that intrauterine migration may be important in preventing embryonic death losses through equal distribution of embryos between the uterine horns. No evidence was found of a genetic basis for intrauterine migration of fertilized ova. Differences between sires and crossbred groups were not significant. (AH al-6)

Four experiments at the Oklahoma Station involving 100 gilts and sows were conducted to test the hypothesis that the daily administration of orally active progestins would reduce early embryonic mortality by enhancing the environment within the uterus. Significant reduction in embryonic mortality occurred only when the embryonic mortality in the control animals approached 30% to 35%. There was an unusually low embryonic mortality in some control groups and a high degree of individual variation. Analysis of pooled data, wherein 33 pregnant animals given the 1 mg. of 17 $\alpha$ -acetoxyprogesterone (17-AP) and 0.5 gamma diethylstilbestrol (DES) per pound of body weight daily were compared with 35 pregnant control animals, indicated a reduction in embryonic mortality (3.39 vs. 4.89 dead embryos) ( $P < 0.17$ ). There was no reduction of embryonic mortality in the 12 pregnant animals given 6 $\alpha$ -methyl-17 $\alpha$ -acetoxyprogesterone (6-M-17-AP) compared with 14 pregnant control animals. The incidence of cystic ovaries at necropsy was 5 of 17 (29.4%) in the 6-M-17-AP treated groups, 4 of 45



(8.9%) in the 17-AP-DES treated groups and 1 of 38 (2.6%) in the control groups. Significant differences in endometrial alkaline and acid phosphatase activities did not occur between groups except when pregnant and nonpregnant animals were compared. (AH al-8)

The effect of exogenous estrogens on corpus luteum maintenance in gilts was studied at the Wisconsin Station. Stilbestrol, estradiol-17- $\beta$ , and estrone maintained functional corpora lutea in gilts when treatment was started by day 11 of the estrous cycle. Estrogen treatment resulted in a decrease ( $P < .01$ ) in corpus luteum weight, and an increase ( $P < .01$ ) in progesterone concentration without altering the total progesterone content of the corpora lutea. Estrone maintained significantly greater size of corpora than did estradiol-17- $\beta$ . Five trials at the Wisconsin Station involving 193 sows and gilts indicate that 6-methyl-17-acetoxypregesterone doses of 100 mg. or greater are required to inhibit estrus and ovulation in the gilt. One or more cystic follicles developed in 58% of the females after withdrawal of eight different hormone doses ranging from 50 to 400 mg. per head per day. Cystic follicles developed during treatment when a low dose of 60 mg. was fed and after treatment when the dose was 240 mg. Gilts fed 75 mg. developed fewer cystic follicles after hormone withdrawal if treatment was started during the follicular rather than the luteal phase of the estrous cycle. Sows maintained preovulatory size follicles for at least eight days after the withdrawal of 200 mg. or more, and gilts maintained preovulatory size follicles for eight days or more after the withdrawal of 400 mg. Sows also reached other dose response end points at a lower level than gilts. Increasing the duration of hormone feeding from 10 to 20 days resulted in more corpora lutea or follicles  $> 6$  mm. in diameter, fewer cystic follicles, and more preovulatory size follicles at eight days after hormone withdrawal. After withdrawal of 240 mg. dose, Yorkshire sows had developed cystic follicles, whereas Duroc sows had developed preovulatory follicles. Neither frequency of feeding the progestational hormone, the energy content, nor the fiber content of the ration affected the probability of ovulation or cystic follicle formation after hormone withdrawal. (AH al-10)

A preliminary study of the influence of different levels of exogenous estrogen on ovarian function in the cycling gilt was initiated in the summer of 1962 at the Nebraska Station. Gilts were assigned at random to the following levels of estradiol-17- $\beta$  as they exhibited their second estrus following the initiation of heat checks: (1) 50  $\mu\text{g}/\text{day}$ , (2) 200  $\mu\text{g}/\text{day}$ , (3) 800  $\mu\text{g}/\text{day}$ , and (4) 1600  $\mu\text{g}/\text{day}$ . Daily injections of estradiol were begun on day 11 of the estrous cycle and continued until slaughter on day 20 or day 31 following pretreatment estrus. Gilts were laparotomized and the corpora lutea marked with India ink on the day treatment was begun. Twenty-two gilts contributed data to this study. Estrous cycle length was not modified by daily injections of either 50 or 200  $\mu\text{g}$ . of estradiol-17- $\beta$ , but was significantly extended by the higher levels of estrogen. All of the gilts receiving 800 and 1600  $\mu\text{g}$ . of estradiol had marked corpora lutea at slaughter on day 31. The gilts that returned to heat prior to slaughter had prolonged estrous cycles. The corpora lutea of the treated gilts were

somewhat lighter in weight than those from control gilts obtained on day 15 of the estrous cycle (285.0 and 256.1 mg. for the 800 and 1600 mg. treatments on day 20 and 285.7 and 285.2 mg. for the 800 and 1600 mg. treatments on day 31 vs. 430.5 mg. for control corpora lutea removed on day 15). The glands are being analyzed for progesterone content. More gilts are being added to this study at the present time. (AH al-7)

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SWINE - NUTRITION AND MANAGEMENT  
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Problem. The changing demands of the consumer to pork with a high proportion of lean are requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation, and the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency.

USDA PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen investigating basic and applied problems in swine production related to nutrition, metabolism, and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Division, the National Institutes of Health, and the Food and Drug Administration. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

The total Federal scientific effort in this area amounts to 7.9 professional man-years. Of this number, 1.0 is devoted to digestion and metabolism, 0.5 to concentrates, evaluation and utilization, 1.5 to forage evaluation and utilization, 3.0 to nutrient requirements, 1.1 to management practices and equipment, and 0.8 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Effects of fiber variation on digestibility. A series of digestibility trials have been conducted at Beltsville to supplement the studies on forage and fiber in swine diets. The diets tested included a conventional diet, one in which corn and cob meal replaced corn, and a third containing 58% ground alfalfa hay. On a dry matter basis these contained 4.0%, 9.1%, and 17.8% of crude fiber, respectively. The diets were evaluated in a series of four digestion trials covering the weight range from 40 to 190 pounds to measure possible effects of age on utilization of feeds containing

widely divergent levels of fiber. Dry matter digestibility of the three diets in ascending order of fiber content was 85.7%, 73.8%, and 62.7% and N retention in the same order was 36.2%, 31.7%, and 22%. Age effect was negligible on dry matter digestibility ranging from 73.0% to 74.5% for the four trials but N retention dropped consistently from 38.9% in trial 1 to 21.0% in trial 4. A complete analysis of the data is in progress. (AH a2-4)

2. Effects of energy level on pigs with genetic differences in performance, type, and breed. An exploratory investigation was initiated at Beltsville last year to study the response of lines, selected either for maximum backfat or for minimum backfat (AH a1-12), to variations in nutritional treatment. The preliminary experiment was conducted with high-fat and low-fat Yorkshires in 1962-63 with pigs pair-fed within each line. One pig in each pair received an estimated metabolizable energy intake equal to two-thirds that of its full-fed mate. Balance trials provide more precise estimates of metabolizable energy content of the diets and measure responses of the different lines to this energy variation. Pigs are slaughtered at various specified ages up to one year and data are obtained on proportions of fat, lean, and bone at these ages.

Growth data from the preliminary experiment showed that pigs from the high-fat Yorkshire line gained 1.00 pound per day and required 3.55 pounds of feed per pound of gain. Comparable figures for the low-fat Yorkshires were 1.02 pound per day and 3.44 pounds of feed per pound of gain. Differences between energy levels were greater with high vs. low energy pigs gaining 1.10 pound and 0.93 pound daily at efficiencies of 3.59 pounds and 3.42 pounds of feed, respectively.

A line project (AH a3-18) has been submitted to expand this phase of digestion and metabolism investigations to include high- and low-fat lines from Duroc as well as Yorkshire swine.

#### B. Concentrates - Evaluation and Utilization

Cottonseed meal. Planned phases of investigation at Beltsville, Maryland, directed at improving the safety and use of cottonseed meal as a swine feed were completed. A final paper on correlation of nutritive indices by rat repletion and T. pyriformis W assay is being prepared. (AH a3-16)

#### C. Forage, Evaluation, and Utilization

Forage and fiber in swine diets. This experimental series at Beltsville is designed to define optimum levels of forage and/or fiber needed to produce a high level of reproductive performance with minimum costs for feed and labor. Gilts fed a pelleted diet containing 55 to 60% ground alfalfa hay (17-18% crude fiber) ad lib. as reported last year produced as well as gilts hand-fed a conventional corn diet (4% fiber) during gestation, and



were superior in reproductive performance to gilts receiving a ground ear corn diet (8% fiber) fed ad lib. in meal form. The satisfactory performance on the high level alfalfa hay diet was nullified by excessive wastage of the feed which could not be prevented under ad lib. feeding. The inferior performance on the ground ear corn diet was believed due to failure of this fiber level (8%) to restrict fatness of the bred gilts.

In order to minimize wastage of feed and more precisely evaluate fiber effects, gilts were allotted to three dietary treatments as they were bred (fall 1962). Planned daily ration for the respective groups was as follows: Group 1 gilt - five pounds basal gestation diet, group 2 gilt - five pounds basal plus 1.5 pounds ground corn cobs, group 3 gilt - five pounds basal plus 3.0 pounds ground corn cobs. Actual daily consumption per gilt was five pounds (basal) in group 1, six pounds (4.62 basal plus 1.38 cob) in group 2, and seven pounds (4.38 basal plus 2.62 cob) in group 3. Group 1 gilts averaged 8.7 pigs born, 7.4 pigs weaned (56 days) at an average weight of 32.1 pounds. Comparable figures for group 2 and group 3 gilts were 9.5, 8.3, and 30.7 pounds, and 9.5, 8.4, and 29.8 pounds.

These results suggest a beneficial effect on reproductive performance from bulk (or fiber) whether derived from hay or cob meal. However, for practical application some form of metering or restriction will be necessary to prevent excessive feed wastage. (AH a2-4)

#### D. Nutritional Requirements - Trace Mineral Requirements and Interrelationships

1. High zinc content in milk and colostrum of sows. Because of the marked variability in response of weanling pigs to low-zinc diets and the apparent importance of milk and colostrum as sources of zinc to suckling animals of some other species, Beltsville researchers have undertaken to determine the zinc content of sow's milk and colostrum. The first assays show 19.44 mg./kg. of zinc in 22 samples of sow colostrum and 8.25 mg./kg. in 15 samples of milk. Reduced to a solids-not-fat basis, the zinc content becomes 90.46 mg./kg. in colostrum and 69.53 mg./kg. in milk. Sow's milk and colostrum according to these figures contain substantially more zinc than milk and colostrum of cow, human, and ewe. Normal milk of these species has been reported to contain from 3 to 5 mg. zinc per kg. of milk which is much higher than the content of other trace minerals, while colostrum zinc is usually 3 to 5 times that of later milk. These figures are believed to be the first published values for swine milk and colostrum. Since all samples were obtained from sows which were on natural diets without supplemental zinc, later samples from supplemented sows may show higher concentrations of this element. (AH a3-12)

2. Zinc metabolism affected by dietary potassium. Beltsville workers have investigated the effects of imbalances of potassium (K) and of phosphorus (P) on zinc (Zn) metabolism in rats. Using a semisynthetic basal diet which contained 1.20% of calcium, variables included two levels

of Zn (18 ppm and 40 ppm), two levels of K (0.1% and 0.65%), and two levels of P (1.2% and 0.3%) in a 2x2x2 factorial design. The higher level of Zn increased rate of growth and efficiency of feed utilization, and produced higher serum phosphatase and higher Zn content in liver and hair with all four combinations of P and K tested. Zinc content of hair from rats on diets low in Zn averaged 129 ppm (range 120-143 ppm) while hair from rats receiving the higher Zn diets averaged 185 ppm (range 146-230 ppm). Levels of P tested had no apparent effect on any of the criteria measured. The higher level of K, like Zn (though to a lesser degree), improved feed utilization and increased growth rate and level of serum phosphatase, but high level K did not affect Zn storage in the liver and was associated with lowered Zn content of hair. (AH a3-12)

3. Factors which affect zinc deficiency in weanling pigs. Past attempts by Beltsville workers to study factors which might influence utilization and requirements of the weanling pig for dietary zinc have been largely nullified by failure to produce characteristic skin lesions of parakeratosis. Since these failures coincided with the addition of supplemental zinc to gestation and lactation diets, recent test pigs were produced by sows which received no supplemental zinc during gestation or lactation. To further enhance the zinc deficiency, dietary factors which might be expected to interfere with zinc absorption or metabolism were included in the treatments. The basal corn-soybean diet containing 1.2% calcium and 31 ppm of zinc was fed to lot 1 pigs (controls), while 1% of sodium phytate was added to lot 2 diet, and cadmium sulfate to supply either 42 ppm or 125 ppm of cadmium was added to diets for lots 3 and 4, respectively. In the control lot, three of four pigs showed some degree of parakeratosis and gained only .38 kilogram per day while all of the pigs in the phytate and low cadmium lots (2 and 3) and two of the four in the high cadmium lot showed marked parakeratosis. Their gains were 0.1, .05, and .08 kilogram per day, respectively. Though not entirely consistent, excretion of uric acid tends to be lower in animals with higher levels of zinc in the liver and higher in active stages of parakeratosis. Sodium phytate appeared to decrease liver storage of zinc and to depress alkaline phosphatase activity in blood, gut, and kidney but without appreciably affecting liver phosphatase. Cadmium supplementation at both levels was associated with erratic and unpredictable levels of zinc in the liver and of enzymatic activity of tissues. (AH a3-12)

4. Sow supplement prevents baby pig anemia. A recent trial at Beltsville confirmed the dramatic breakthrough by University of Kentucky researchers in the field of baby pig anemia. Blood tests on 36 litters of pigs demonstrated that a new iron compound when fed to a sow from four or five days prepartum through lactation will maintain adequate levels of hemoglobin in the blood of her suckling pigs. While hemoglobin increase is not quite as pronounced during the baby pig's first week of life as the increase due to injectable iron-dextran, it continues a steady buildup until it reaches the same level at from three to four weeks of age. (AH a3-12)



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Nutritional Requirements

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Management Practices, Equipment, and Facilities

- Agrisearch Note: Mobile air conditioner for sows. Agr. Res. Mar. 1963, p. 15. (AH a2-3)

INFECTIOUS AND NON-INFECTIOUS DISEASES OF SWINE  
Animal Disease and Parasite Research Division, ARS

Problem. Profitable swine production depends largely on the ability to control diseases. Swine diseases cause losses estimated at more than \$200 million annually. In order to control and eventually eradicate these diseases, a thorough knowledge of causes, diagnostic procedures, preventive procedures, and treatments is required. Although a great deal of excellent research has been and is being accomplished, a vast amount of research is still required to obtain this knowledge. At present, the causes of several important swine diseases are unknown or incompletely understood. Extensive fundamental research on swine diseases is essential to the welfare of the swine industry.

USDA PROGRAM

The Department has a long history of swine disease research. For example, research on hog cholera was initiated in 1884. Research on this and other important swine diseases is a continuing long-term program. Modern research techniques in the areas of biochemistry, biophysics, pathology, microbiology, pharmacology, physiology, and immunology, are being applied to swine disease problems. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 23.3 professional man years. This effort is divided among sub-headings as follows:

Hog Cholera 9.1 at the National Animal Disease Laboratory, Ames, Iowa, the Florida Hog Cholera Research Station, Live Oak, Florida, under a cooperative agreement with the University of Illinois, and under a contract with the University of Nebraska.

Atrophic Rhinitis 4.0 at the National Animal Disease Laboratory, Ames, Iowa.

Transmissible Gastroenteritis 3.6 at the National Animal Disease Laboratory, Ames, Iowa, and under cooperative agreements with Purdue University and the University of California, and a memorandum of understanding with the University of Illinois.

Erysipelas 3.6 at the National Animal Disease Laboratory, Ames, Iowa, under a cooperative agreement with the Department of Biochemistry, Seton Hall College of Medicine and Dentistry, Jersey City, New Jersey, and in connection with a PL 480 grant to the Institute for Veterinary Research, Pulawy, Poland.

Brucellosis 3.0 at the National Animal Disease Laboratory, Ames, Iowa.



## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Hog Cholera

Hog cholera research at the National Animal Disease Laboratory, Ames, Iowa, was conducted in the following phases:

Propagation of hog cholera virus in vitro. A method of identifying hog cholera virus in animal tissues by the use of immunofluorescence has been developed. The virus is grown in swine kidney cells and stained with a fluorescence stain and examined under a special microscope to demonstrate the virus-infected cells. This test has proved about 98 percent efficient in detecting hog cholera in experimental animals. The efficiency of this test in diagnosing field cases of hog cholera is being investigated.

Antigenic relationship between hog cholera and bovine viral diarrhea. Specific staining of antigen within bovine embryo kidney tissue culture cells, infected with either Oregon C24V or NADL-MD bovine viral diarrhea virus, was accomplished using fluorescein-conjugated swine anti-hog cholera or bovine anti-viral diarrhea globulin. Also specific staining of antigen within pig kidney tissue culture cells, infected with hog cholera virus, was accomplished using the same two types of conjugates. Specificity was confirmed by appropriate controls.

Agar-gel diffusion studies for diagnosing hog cholera. A comprehensive investigation of this serological procedure gave no evidence that the observed precipitation reactions were related to hog cholera virus and its corresponding antibody. (ADP a2-17(C))

Pilot hog cholera eradication field studies to evaluate hog cholera vaccines. The evaluation of experimental field trial hog cholera eradication, using modified live virus vaccines, has continued in Suwannee County, Florida, from April 1957 to December 31, 1962. During this period the study was designed to measure the potency, safety, and shelf life of three types of commercial modified live-virus vaccines (lapine, porcine, and tissue culture origin) administered with a minimum of 15 ml of anti-hog cholera serum. Records were made of all vaccinated and unvaccinated swine herds, purchased or raised, and approximately 4.5 percent of the vaccinated swine were challenged with virulent virus at market age to measure their immunity from vaccination. All suspected hog cholera outbreaks in the county were investigated and swine inoculation tests made for confirmation of the disease virus.

Since December 31, 1962, the field trial study has been changed to measure the spreading characteristics of modified live virus vaccines administered with and without hog cholera antiserum.

During the period 1957-1962, data collected from challenge of 4073 swine vaccinated with 87 serial numbers of lapine origin, porcine origin or tissue

culture modified live virus vaccines from 11 licensees show an inverse relationship between average age of vaccine at time of use and immunogenicity of vaccine. Hog cholera was confirmed in six vaccinated, farm-raised swine, in nine non-vaccinated, farm-raised swine, and in two vaccinated, purchased hogs. The difficulty of enforcing regulations restricting movement of non-vaccinated swine from public market premises has been described. Adherence to quarantine provisions by most swine-raisers and effective enforcement of regulations affecting swine transportation by the Florida Division of Animal Industry have been reported.

During fiscal year 1962, a similar field trial cooperative study with the Animal Disease Eradication Division of ARS and the State of Georgia, was started in Lowndes County, Georgia. This pilot plant study is being made to evaluate inactivated or killed hog cholera virus vaccines as an eradication tool. The study has been in progress for over 18 months without the development of a single confirmed case of hog cholera. (ADP a2-13)

The Hemagglutination test for diagnosing hog cholera. This investigation is being carried out under a cooperative agreement at the University of Illinois. Evaluation of the hemagglutination test has shown that it is not sufficiently reliable, in its present form, to be used for routine diagnosis of hog cholera. It appears that the major difficulty is the tendency of the formalinized erythrocytes to agglutinate spontaneously. Work is continuing to improve specificity through the preparation of a more stable erythrocyte suspension and by purification of hog cholera virus and concentration of hog cholera antibodies. (ADP a2-17(C))

#### B. Atrophic Rhinitis

In studies of atrophic rhinitis at the National Animal Disease Laboratory, 113 swine were examined with a rhinoscope. The rhinoscopic examination was compared with a subsequent postmortem examination. Both examinations had a 60.1% agreement for the degree of atrophy, which included 86.0% agreement of the negatives but only 16.7% of the positives. According to biometric analysis, the correlation between the postmortem and rhinoscopic scores for this group was +0.75.

The results indicate that the rhinoscope may have some value as a diagnostic tool but is not reliable for research purposes. (ADP a2-8(Rev.))

#### C. Transmissible gastroenteritis (TGE)

Research investigations on TGE at the National Animal Disease Laboratory were continued with emphasis on the development of methods for diagnosis, prevention and control. This work has not, as yet, progressed to the reporting stage.

At the University of California the interrelationship of swine enteroviruses was investigated. (ADP a2-10(Rev.))



At Purdue University investigations were carried out on attempts to propagate TGE virus in laboratory animals, embryonating chicken eggs, and tissue and organ cultures. In addition, the mechanism whereby immunity is transferred from sows to pigs was investigated. (ADP a2-10(Rev.)

D. Swine erysipelas

A type-specific antigen has been isolated from acetone dried cells of Erysipelothrix and after extensive purification has been shown to be composed of a polymer of hexosamines to which peptide components are attached. This mucopeptide antigen is most probably derived from the cell wall of the organism. The antigen isolated in this manner is identical both chemically and serologically with the antigen present in acid extracts of the organism. It was acid extracts of cells of Erysipelothrix which were used originally to establish types and strains of the organism. (ADP a2-15)

E. Brucellosis

Work on swine brucellosis at the National Animal Disease Laboratory was carried out on the serology, bacteriology and histopathology of this disease. This work has not, as yet, progressed to the reporting stage. (ADP a2-16)

F. PL 480 Project

1. Studies on the Antigenic Structure of Erysipelothrix rhusiopathiae.

This investigation is carried out under a PL 480 Grant to the Institute for Veterinary Research, Pulawy, Poland. The work, still in the preliminary stage, is aimed at improving diagnostic and immunizing procedures. (E21-ADP-8)

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FOOT-AND-MOUTH AND OTHER EXOTIC DISEASES OF SWINE  
Animal Disease and Parasite Research Division, ARS

Problem. Foreign diseases, such as foot-and-mouth disease, African swine fever, and Teschen disease, that occur elsewhere in the world, constitute calculable potential threats to the swine industry of the United States. Foot-and-mouth disease is of particular importance because the disease frequently occurs primarily in swine from which it spreads to other susceptible species, such as cattle and other ruminants. African swine fever, which until recently was confined to wild and domestic pigs in Africa, has spread to Portugal and Spain. The disease is of special concern because of its resemblance to hog cholera, with which it may be confused. Moreover, mortality from the disease approaches 100 per cent, and there is no specific preventive vaccine. Teschen disease, which causes widespread inapparent infections and occasional involvement of the central nervous system, is another of the foreign diseases to be guarded against. A disease indistinguishable from Teschen disease has appeared in England in recent years. Despite all precautions, any of these diseases may occur in the United States, as likely as not through the medium of modern, rapid international transportation. The Plum Island Animal Disease Laboratory is engaged in studies of foreign diseases of swine, for the purpose of developing information for increased protection of the Nation's swine industry.

USDA PROGRAM

The Department has a continuing long-term program involving veterinarians, biochemists, microbiologists, and pathologists, engaged in basic and applied research in this problem area. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 6.6 professional man years. This effort is divided among sub-headings as follows:

Foot-and-Mouth Disease of Swine 1.0 at the Plum Island Animal Disease Laboratory, Plum Island, New York.

African Swine Fever 4.6 at the Plum Island Animal Disease Laboratory in cooperation with the East African Veterinary Research Organization, Muguga, Kenya, and in connection with a PL 480 project in Madrid, Spain, where the equivalent of \$97,550 has been made available to the Spanish Ministry of Agriculture over a 3-year period.

Rinderpest in pigs 1.0 at the Plum Island Animal Disease Laboratory, Plum Island, New York.

## REPORT OF PROGRESS FOR USDA

Foot-and-mouth Disease of Swine

No report for this reporting period. (ADP a9-1(Rev.))

A. African Swine Fever

As the result of work with killed and attenuated vaccine, anti-African swine fever serum to 5 isolates of the virus is now available. Six isolates of the virus have been adapted to pig kidney culture and 3 have been attenuated by serial passage in leucocytes to produce survivor animals for serum production and cross-challenge studies. Of the 35 isolates with African swine fever virus presently available, 11 originated in domestic pigs, 17 in wart hogs, 5 in bush pigs and 1 each in porcupine and hippopotamus. The hyena may also be implicated as a carrier of African swine fever.

African swine fever infected tissue culture fluid may be fractionated to separate the virus with an 80-fold increase in purity and yield 3 non-infectious fractions. One of the fractions reacts in the agar gel test with 4 different antisera; another is specific only with early convalescent serum, and the third specific only with homologous sera. Each fraction has been inoculated into rabbits to produce antisera.

In comparative studies of African swine fever and hog cholera, it has been shown that the two diseases are strikingly similar. It has also been shown that pigs immune to African swine fever virus are fully susceptible to hog cholera virus. This method may be used to differentiate the two.

In thermal studies with the virus it has been shown that African swine fever virus remained infective after treatment at 56°C for 80 minutes but not after 120 minutes. The virus was not infective after heating at 81°C for 2 minutes. (ADP a9-2(Rev.))

During the life of the PL 480 agreement, the Spanish have examined the test rather exhaustively in that 803 samples have been tested. Of these 803, 595 samples were positive to the hemadsorption test. Sixty-eight percent of the positive samples were examined and African swine fever virus was demonstrated in each sample. Confirmation was obtained by inoculating swine with the test material. Similarly, 49 samples which were negative to the hemadsorption test, were examined by animal inoculation and all 49 samples were shown to be free of African swine fever virus. (E25-ADP-4)

B. Rinderpest in Pigs

Little attention has been given to the study of rinderpest in pigs. This indifference probably stemmed from the unfounded belief that European breeds of swine were not susceptible and because management practices in rinderpest



infected areas populated with European pigs do not lend themselves to extensive mixing of cattle and swine.

Results of work at the Plum Island Animal Disease Laboratory show that pigs may acquire "silent" infection from cattle, carry rinderpest virus for approximately 2 weeks, and thereby provide a dangerous source of infection. Continued passage of the virus in pigs does not appear to increase its virulence.

Studies with blood of rinderpest-infected pigs have resulted in findings which may be used for diagnosis. Post-mortem examination of pigs infected with rinderpest virus are of little diagnostic value because tissue changes are minimal. This observation led to the conduct of a study to determine if microscopic tissue changes could be detected. Those organs with lymphoid tissues were found to be affected and the character of the change is sufficiently distinctive for use in differential diagnosis.

Pigs did not show clinical signs of infection when inoculated with a tissue culture modified strain of rinderpest virus which was developed for use as an immunizing virus for cattle. (ADP a9-3)

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PARASITES AND PARASITIC DISEASES OF SWINE  
Animal Disease and Parasite Research Division, ARS

Problem. Parasitic diseases have been estimated to cost the swine industry of the United States at least \$200 million annually. These diseases for the most part are cosmopolitan. Subclinical infections are the most frequent type and the most costly, yet they are generally so difficult to recognize that they often are overlooked entirely. Diagnosis is difficult, and successful treatments for many of these parasitisms are not available. Moreover, management practices to avoid the spread of parasitisms and to control them are often ineffectual. The problem is to develop, through a planned, balanced program of basic and applied research, knowledge for preventing, controlling, or eradicating parasitic diseases so as to provide for healthy swine, insure adequate supplies of parasite-free pork for an expanding population, avoid or minimize economic losses caused by these diseases, and thereby contribute to a prosperous agriculture, a sound national economy, a high standard of living, and a healthy population.

USDA PROGRAM

The Department has a continuing long-term program involving parasitologists, veterinarians, biochemists, microbiologists, and pathologists engaged in basic and applied research in this problem area. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 4.7 professional man years. This effort is divided among sub-headings as follows:

The role of parasites in the economy of swine production 1.2 at the Beltsville Parasitological Laboratory, Beltsville, Maryland, and at the Divisions laboratory at Tifton, Georgia, through informal cooperation with the Georgia Coastal Plain Experiment Station.

Bionomics and pathogenicity of the swine whipworm 0.5 at the Beltsville Parasitological Laboratory.

Swine kidney worms 2.1 at Tifton, Georgia, the Beltsville Parasitological Laboratory, and under cooperative agreement with the North Carolina Agricultural Experiment Station at Raleigh.

Investigations of *Trichinella spiralis* 0.5 at the Beltsville Parasitological Laboratory.

Effect of anthelmintic treatment on rate of gain 0.3 at Tifton, Georgia.

Pathogenic role of the intestinal roundworm 0.1 under a cooperative agreement with the Nebraska Agricultural Experiment Station at Lincoln.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Swine kidney worms.

Past research results have shown that the swine kidneyworm, Stephanurus dentatus, can be completely eradicated from an infested area through herd management. The management system consists of using only gilts for breeders and removing all older animals from the farm as well as the breeders after pigs are weaned.

Application of the "gilt only" system of herd management now in progress under farm conditions seems to support the research results - that kidneyworm can be eradicated from infested farms in 2 years or less.

At the North Carolina Agricultural Experiment Station, several organophosphate compounds were given to kidneyworm-infested swine to determine their influence on ova production. None of the compounds decreased ova production when used at a safe dosage level. Studies were continued to determine if prenatal infection with swine kidneyworms occurs. (ADP b2-11(R))

B. Intestinal threadworms.

The intestinal threadworm, Strongyloides ransomi, causes heavy losses in baby pigs in the North Florida and South Georgia area. It has now been demonstrated that S. ransomi infection of weaned pigs can reduce the weight gain and efficiency of pigs. The extra feed necessary for an infected pig to reach market weight may cost as much as \$3.70 more than that for an uninfected animal. (ADP b2-17)

C. Intestinal roundworms.

At the Nebraska Agricultural Experiment Station, Lincoln, immunity to migrating Ascaris suum was induced in pigs by administering three oral inoculations of ascaris eggs at 10-day intervals. Fifteen days following the last immunizing dose, the pigs were challenged with 100,000 infective eggs. Pigs, receiving their first inoculations at 2 weeks of age, developed a poor immunity. Pigs placed on trial at 4 months of age (and previously infected with ascaris) had the best immunity.

CoRal at 20 parts per million continuously in diet of growing-finishing swine did not depress Ascaris infections. It inhibited fly development in the feces of the treated pigs.

Oil suspensions of thiabendazole stopped the migratory stage of Ascaris in baby pigs but have a short residual effect. (ADP b2-12(Rev.))



D. PL 480 Project.1. Investigations on Trichinellosis with special reference to epizootiology, immunology and pathogenesis.

Investigations are being conducted at the Polish Academy of Science, Warsaw, on the epidemiological, epizootiological, and immunological aspects of trichinosis. Arrangements have been made with 6 sources of human autopsy material for the examination of tissues for trichinae. Forty-five samples of such tissues have already been examined. Microscopic and digestion techniques are used for these examinations. Studies of the incidence of trichinae in domestic dogs and cats, and in wild carnivores (foxes, etc.), are also being carried out. Seventy-five specimens from these sources have been examined. Pigs, rabbits and mice have been experimentally infected with trichinae and will be used to develop an antigen for use in the laboratory and field diagnosis of trichinosis. (E21-ADP-9)

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SWINE INSECTS  
Entomology Research Division, ARS

Problem: Insects and ticks irritate and torment livestock throughout the year in all parts of the United States and cause serious losses. These pests reduce weight gains, lower the quality of meat and hides, and spread numerous animal diseases. Livestock losses directly attributable to insects and ticks are estimated to exceed \$300 million annually. Practical but not adequate control methods have been developed for lice, screwworms, ticks, bots, grubs, and other insects, but satisfactory methods of protecting cattle from horse flies, deer flies, stable flies, mosquitoes, and the newly introduced face fly remain an unsolved problem. The development of insecticides for use on beef cattle, horses, and swine has been hampered because certain insects have become resistant to various insecticides, and because harmful residues have been found in meat following the application of certain materials. Safe, effective, nonresidue-forming insecticides and repellents are required. New approaches to control, including radiation and chemosterilants, should be explored to determine their feasibility as practical control methods. Efforts also need to be made to find and evaluate insect pathogens, parasites, and predators for controlling certain livestock pests. Expanded basic studies on the biology and physiology of these pests are needed to find weak links in their life cycles that will serve as a basis for the development of more effective and safer methods of control. Research also is urgently needed on the role of insects in the spread of diseases of livestock.

USDA PROGRAM

The Department has a continuing, long-term program involving basic and applied research on insects and ticks which affect the health and productivity of beef cattle, horses, and swine. Studies are conducted on the biology, physiology, genetics, and nutrition of the screw-worm, stable fly, horn fly, house fly, mosquitoes and other pests; on the nature of insect resistance to insecticides; and on absorption, metabolism and excretion of insecticides by insects feeding on or in animals; the effects of irradiation and chemosterilants on insects; insect attractants and repellents; and other new approaches to control. Research is concerned with the development of more effective contact and systemic insecticides and protective treatments for the control of livestock pests. Studies are conducted to determine the occurrence of residues in tissues of animals treated with insecticides. Minor consideration is given to the development of sanitation and management procedures and biological control methods, including parasites and predators, for controlling the face fly, stable fly and several other pests. Emphasis is also given to the development of insect sterility, attractants and



various other noninsecticidal approaches to control. Studies are conducted in cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions to evaluate various kinds of traps and devices for estimating and controlling natural insect populations, and improved or special equipment for the application of insecticides to animals. Limited research is conducted on the role of insects and ticks as vectors of livestock diseases, with particular emphasis on bovine anaplasmosis and equine piroplasmosis. The Federal scientific effort devoted to research in this area totals 16.3 professional man-years. Of this number, 6.1 is devoted to basic biology, physiology and nutrition; 3.9 to insecticidal and sanitation control; 2.0 to insecticide residue determinations; 0.2 to biological control; 2.0 to insect sterility, attractants and other new approaches to control; 0.2 to the evaluation of equipment; 0.8 to insect vectors of diseases; and 1.1 to program leadership.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Basic Biology, Physiology and Nutrition

1. Mosquitoes. At Corvallis, Oreg., and Fresno, Calif., studies were continued on the biology and ecology of important mosquito species. In laboratory tests the majority of Culex tarsalis females preferred to feed at the higher of two feeding locations and preferred mice rather than chickens for their source of blood.

A study was conducted on the daily activity of several species of mosquitoes -- Anopheles freeborni, Culex peus, Culiseta inornata, Culex incidens, and Culex tarsalis. All species behaved similarly. Both males and females began to move out of daytime resting shelters a few minutes before or after sunset. Only a few males and females (0.3 to 2.8%) remained in the shelters during the night. Adults did not begin to return to the shelters until sunrise or a few minutes later, and all did not return until sometime after 8:00 a.m. Exodus from and return to shelters appeared to be regulated by light intensity. Other factors such as preconditioning to light cycles, temperature, and humidity, may have had some effect since artificial lights did not prevent mosquitoes from leaving shelters eventually, but did change their time and rate of leaving. Use of special crosses of resistant and susceptible strains of Culex tarsalis showed that some of the females mate more than one time and utilize sperm from more than one mating.

Taxonomic studies defined suitable characters for separating dark-winged forms of Aedes dorsalis from A. melanimon and determined that these two forms coexist in only one area (Solano County, Calif.). Surveys at Borrego Springs (San Diego County, Calif.) were made to find isolated populations of mosquitoes for future studies on control through sterilization.

Surveys were continued on biting arthropods of the Humboldt River Basin in Nevada. During April, May, and June, water was plentiful and high populations of Aedes melanimon, A. dorsalis, A. vexans, Culex tarsalis, and Culiseta inornata were found. Mosquito larvae were found infected with a



microsporidian, Thelohania sp. and a bacterium, both of which are under study as biological control agents. In late July, no floodwater Aedes breeding was observed, but moderate breeding of Culex tarsalis and Culiseta inornata was observed. Studies of mosquito larval populations in typical breeding areas in dairy drains and culverts in California during April indicated the presence of Culiseta inornata, Culiseta incidens, Culex tarsalis, Culex peus, Culex apicalis, and Anopheles franciscanus. No breeding of Culex quinquefasciatus was found.

In Oregon, using C-14 labeled TDE, slight but consistent differences in the rate of degradation of TDE have been noted in susceptible and resistant strains of Culex tarsalis, indicating that the main source of resistance to this chemical is increased degradation of TDE to FW-152 and water soluble metabolites through an oxidative rather than a dehydrochlorination mechanism. Further tests with DDT and TDE have shown that analogs of DDT, which block metabolism via the oxidative pathway, overcome resistance to DDT and tend to confirm the hypothesis that resistance to DDT and TDE in tarsalis is due to a more rapid oxidative metabolism of the insecticide.

Early in July 1962, reports were received of a serious mosquito outbreak in the cattle-growing areas along the Gulf Coast of Louisiana and Texas. Surveys in these areas revealed a heavy mosquito population resulting from successive broods of mosquitoes over a period of 6-8 weeks. At the time of the survey, the spring calf crop had been decimated and hundreds of mature cattle had perished from the attacks of mosquitoes. Growers had sold or moved thousands of animals to avoid further losses. The loss incurred by cattlemen was estimated at \$250,000. Because of the large area involved, control of the mosquitoes was not feasible.

2. Stable Fly. In Texas stable flies began to feed when they were only 4 hours old. The adults did not feed well or survive long on deer blood or several synthetic diets. They thrived on beef blood and beef serum but not on blood cells alone. At 80°F. and 50-60% relative humidity first matings occurred when the flies were 3 days old and 84% mated within 5 days. At 80°F. and 10-30% relative humidity mating did not begin until flies were 4 days old and only 12% mated in 5 days. No mating whatever occurred at 68°F. and uncontrolled humidity.

Stable fly larvae were not adversely affected by 17 hours of submergence in water, but 100% mortality resulted from 24 hours submergence. Exposure of pupae in water for 17 hours resulted in retarded development and greatly reduced adult emergence.

In Oregon field studies determined the dispersal pattern of marked adult stable flies. Flies were recovered over 14 miles from the point of release in 24-48 hours.



3. Horn Fly. In Texas, after considerable trial and error, a technique was developed for colonizing the horn fly in the laboratory without access to a bovine host. The diet consisted of 1 part bovine blood and 1 part beef juice plus 1 mg. of streptomycin, 1000 units of penicillin and 250 units of mycostatin per ml. of diet. Flies were fed by placing a cotton pad soaked with the diet on top of the holding cages. Cages consisted of 4" lengths of 6" plastic tubing with ends of plastic screen. Eggs were deposited on the plastic screen. Optimum conditions for adult reproduction were 90°F. temperature and 60-80% relative humidity. The colonization procedure is easy and inexpensive and greatly facilitates laboratory testing of insecticides, chemosterilants and repellents at all seasons of the year. Adult flies survived for 96 hours in a room kept at 75-80°F. and 62-67% relative humidity. Only a few survived in a room kept at 85-92°F. and 34-40% relative humidity.

In Oregon field studies determined the pattern of dispersal of marked adult horn flies. Flies were recovered over 7 miles from the point of release in 24-48 hours.

4. Screw-worm. Research on the screw-worm was discontinued at Kerrville, Tex., in September 1962 and moved to Mission, Tex., headquarters of the Southwest eradication campaign. This included research on the biology and ecology of the screw-worm under field conditions, vigor and longevity of sterilized flies, effects of radiation, the development of genetically marked strains, cytological studies with irradiated flies, nutrition, and special tests related to problems in the sterile male release program.

A new technique to determine the mating aggressiveness of sterilized or mutant screw-worm flies was developed. It was observed that in laboratory cages males harassed females sufficiently to cause mortality greater than that occurring when females were caged without males--in general, higher ratios of males to females caused greater mortality than lower ratios. Tests with various strains of screw-worms of known sexual competitiveness in comparison with other mating aggressiveness tests confirmed the validity of the method. Since the criterion for mating aggressiveness is the mortality of females over time rather than egg production and viability, the time, space, and labor required to determine sexual aggressiveness were greatly reduced. Studies confirmed optimum numbers of screw-worm larvae per tray for rearing efficiency and optimum numbers of adults per cage for mating and longevity studies. They also confirmed diurnal periodicity in screw-worm pupae for emergence occurred from sunrise until noon. Studies indicated that the use of CO<sub>2</sub> as anesthesia for screw-worms is safe for handling young screw-worm adults for longevity and mating tests and scanning for genetic markers.



Research was continued to find and develop genetically distinct strains of screw-worm flies and to study these mutant flies. In the adults many genetic markers were found such as yellow eyes and white auxillary region ("Whaxy"). The genetic marker "Whaxy" affects the morphology of both the adult and larvae--a factor which would be invaluable in field studies. Approximately 270,000 screw-worm larvae were examined for morphological variants and from this 221 cultures were studied as possible genetic strains. Of markers found in the immature forms, at present three morphological characters--interrupted bands of segmental spines, two spiracular openings in the anal plates of third-instar larvae, and additional spines on the eleventh anterior segmental band--were demonstrated to be genetic in nature. None of these were established as a pure strain. Research with these and other mutant strains is being pursued to determine the genetics of the strains and if these strains are as vigorous and aggressive as the normal strain, factors which are essential if the strains are to be used in the release program. For example, preliminary genetic studies indicate that the "Whaxy" mutant is lethal in the homozygous state with only a few individuals escaping. Other strains have slight behavioral differences from the normal strain, i. e., they respond differently to attractants and survey traps.

When pupae of the screw-worm were irradiated in an atmosphere of CO<sub>2</sub> and air (50-50 mixture), damage to the reproductive system of the adult female was greater than that induced by a similar radiation treatment in air. When the pupae were pretreated in the gas mixture for approximately 45 minutes, complete sterility was induced by a treatment of 4,500 r delivered in CO<sub>2</sub> and air, whereas irradiation in air alone required about 5,500 to 6,200 r. Techniques were developed to study the cytological effects of radiation and chemosterilants on screw-worm, particularly on spermatogenesis and oogenesis. Preliminary studies revealed chromosomal aberrations severe enough to cause dominant lethality. Considerable data on oogenesis and spermatogenesis in normal screw-worm flies were accumulated as necessary background data for evaluating the effects of radiation and chemosterilants on reproduction.

For rearing larvae of the screw-worm, a synthetic diet was developed that contained casein, yeast extract, cholesterol, inorganic salts, water, and agar. This medium was further defined by replacement of casein with a mixture of L-isomer amino acids, and of yeast extract with a mixture of B-vitamin and RNA. Larval growth and development on the defined medium were nearly equal to that on media containing casein and yeast. Larvae



absolutely required thiamine, riboflavin, panthothenate, niacin, and choline for growth. Biotin and folic acid stimulated growth and were necessary for maturation to the adult stage. Pyridoxine and its analogs, pyridoxal and pyridoxamine, inositol, B<sub>12</sub>, and carnitine had no effect on growth. Niacinamide spared niacin, but p-aminobenzoic acid had no effect on the folic acid requirement.

Studies on the effect of dessication, lack of adult food, reduced temperature, age of flies at time of release, and the effect of all of these factors on different strains of the screw-worm were undertaken to improve the survival of screw-worm flies released into the hot and dry climate of Texas. Provision of food in release cartons or the judicious use of reduced holding temperatures curtailed mortality prior to or shortly after release. Techniques need to be developed which would allow greater uniformity in age of flies at the time of release. Newly emerged flies carry a food and water reserve that will sustain them up to 24 hours (90°F. and 30% R.H.) compared to only 3 to 4 hours for 2-day-old flies. Selection of flies for individuals more capable of survival under unfavorable conditions has shown promising results.

Extensive studies were made of the ecology of screw-worm flies under field conditions by releasing tagged flies. It was determined that flies tend to congregate and disperse along water courses or streams and are capable of traveling long distances. This research resulted in the addition of strategic releases of screw-worms along water courses and an increase in the effectiveness of the sterile-male release program.

5. House flies. At Orlando, Fla., research on control or eradication through the use of sterilization by radiation or chemicals has shown that considerable gaps exist in knowledge of the biology and mating behavior of house flies. Mating tests have shown that both males and females must undergo a sexual maturation time of at least 16 hours with males and a minimum of 24 hours with females. Once the mating drive has started, males will attempt to "strike" or mate with both males and females and certain inanimate objects, although they "strike" more readily and frequently with females. This fact along with experiments in a large cage-type chemotactometer suggested the presence of some type of a female sex attractant of a low order. Imperfect sex recognition in the male combined with a low order sex attractant in the female would account for the fact that males attempt to mate with either sex and result in the higher ratio of male-to-female "strikes." Quantitative data on the male and female mating behavior and a detailed description of the mating "strike" of the male and mating behavior of the male and female have been developed. Males or females which had their wings removed were able to mate with individuals of the opposite sex with wings. Amputation of more than one pair of legs from the male prevented mating, while amputation of only one pair of legs impeded but did not prevent mating.



Tests were run to determine the actual time house flies remain in copula after initial seizure. Of 61 mating pairs that were trapped and observed, the shortest mating period was 44 minutes and longest, 96 minutes. The average was 60 minutes. Females examined after only 1 and 2 minutes of mating contained no sperm. Those examined after 3 to 5 minutes of mating had spermathecae which contained a few sperm and some which were completely filled. After mating for periods of 10 to 76 minutes, the spermathecae were filled to capacity with sperm, with only one exception.

Eighty-six female house flies reared in the laboratory laid an average of 94.4 eggs per female of which 89% hatched. The number of eggs laid varied from 12 to 186 per female. Under laboratory conditions some flies fed within an hour after emergence; others did not feed until later and some did not feed until they were 16 to 18 hours old.

At Corvallis, Oreg., studies were continued on the physiology of resistant and susceptible house flies. Isolan-resistant house flies have decreased ali-esterase activity and increased Isolan-detoxifying enzyme. Techniques using high-speed centrifugation have been developed which concentrate enzymes important in metabolizing or conferring resistance to organo-phosphorus compounds. In the case of malathion-resistant house flies, the nature of the alkyl groups attached directly to the phosphorus atom is the major factor in resistance. Thus, the primary cause of resistance is probably associated with the rate of recovery of the phosphorylated detoxifying enzyme after poisoning, rather than with an increased ability to cleave the toxic molecule per se.

In Oregon extensive studies were conducted on the biology, nutrition, and colonization of the little house fly (Fannia canicularis). After much trial and error a satisfactory rearing medium was developed which consisted of alfalfa meal, yeast extract solution and wood shavings. Adult flies were held in standard cages and provided with wrinkled balls of black muslin impregnated with alfalfa and yeast extracts for oviposition sites. Under such conditions 48% of the females and 25% of the males survived for 22 days in cages kept at 70-80°F. At 90°F. no males and only 8% of the females survived for 22 days. Egg deposition was about 5 times as great at 80°F. as at 70° or 90°F. Females began ovipositing in 5-6 days at 90°F., 8-9 days at 80°F. and 10-11 days at 70°F. The eggs dessicate rapidly and must be kept constantly on a moist surface to insure a high percentage of hatch.

6. Horse Flies and Deer Flies. Studies were continued in Mississippi on the biology of tabanids. First adults of Hybomitra lasiophthalmus were noted on March 28. By mid-April this species was abundant and small numbers of T. vittiger schwardti and T. fuscicostatus were present. The usual succession of species appeared during the summer and early fall months but none reached their usual abundance. Population declined drastically during the latter part of July as a result of prolonged drouth. Populations rose only slightly following rains in late August.



7. Lice. Studies in Oregon showed that low louse populations on cattle during the summer months are largely due to destruction from licking. Short summer hair coats do not protect the lice, whereas long winter coats do. When short coated animals were restrained from licking themselves, heavy louse populations developed in 3-4 weeks.

8. Ticks. Observations in Texas showed that the lone star tick became active in January 1962, and population on cattle increased gradually during February, March and April, reaching a peak in May and June. Tick populations began to decline in July and had virtually disappeared by September.

The winter tick first appeared on cattle in October 1962, and populations gradually increased to a peak in December 1962, and January 1963. Tick populations declined rapidly in February and had virtually disappeared by late March.

## B. Insecticidal and Sanitation Control

1. Mosquitoes. Studies were continued at Orlando, Fla., to find new and effective insecticides for the control of mosquitoes. In screening tests with Anopheles quadrimaculatus larvae, 28 of 81 compounds tested were rated Class IV in effectiveness. Four of these compounds--American Cyanamid CL-18133, Stauffer B-10046, Stauffer 8-10094, and Bayer 47940--were highly effective, killing 100% of the larvae at concentrations of 0.05 to 0.01 p.p.m. One hundred and nine plant extracts were also screened for toxicity, but none of these were toxic at low concentrations. Of 83 compounds tested against female Aedes taeniorhynchus in wind tunnel tests, 7 were as effective as the standard, malathion. Dimethrin in granular formulations was effective in laboratory and field tests as a larvicide against Anopheles quadrimaculatus, Aedes aegypti, Aedes taeniorhynchus and Culex quinquefasciatus mosquitoes. A mixture of DDT and an anti-resistant compound was no more effective than DDT alone against C. quinquefasciatus larvae.

In Oregon, studies were continued to find repellents for protecting animals from attacks by mosquitoes. Only one (ENT-26455) of 91 compounds tested was a highly effective repellent. This material showed 100% repellency for 24 hours and from 50 to 90% repellency after 48 hours. Several materials were highly effective toxicants but none was superior to the standard, Bayer 29493.

In Oregon, 46 compounds were tested for systemic action by giving them orally to mice and allowing mosquitoes to feed on the mice. At a dosage of 100 mg./kg., two compounds--Bayer 29493 and Shell SD 8436--killed all mosquitoes for 6 hours after the mice had been treated.

2. Stable Fly. In Texas, 240 compounds were screened in spot tests on cattle for repellency and toxicity against the stable fly. Of these materials, 6 were Class IV repellents at 5% and 21 were Class IV toxicants at 0.5%. A number of other materials were Class IV at higher concentrations. The outstanding repellents were ENT-20274, ENT-25927, ENT-26864, ENT-32965, ENT-25946, and ENT-27031.

Tests were conducted with the WHO test kit to determine the susceptibility of non-resistant stable flies to DDT and dieldrin. At an exposure of 30 minutes the LD-50s and LD-90s for DDT were 1.7 and 2.6% and for dieldrin 0.36 and 0.91%, respectively.

In field tests in Nebraska, applications of 1 pint of 0.5% Ciodrin to cattle gave good control of stable flies for 3-4 days. Daily applications with an automatic sprayer of 100 cc of 0.8% Ciodrin maintained very good control of stable flies. In field tests in Texas, sprays of 0.25% DOWCO 175 (ENT-25964) applied at the rate of 2 quarts per animal gave excellent control of stable flies for 3 days.

3. Horn Fly. Extensive field tests were conducted in Texas, Mississippi, Nebraska, and Oregon, to compare several old and promising new insecticides for the control of horn flies on cattle. In Texas sprays of 0.25 and 0.5% Hooker 1422 (ENT-25780) applied at the rate of 2 quarts per animal provided effective control of horn flies for 7-10 days. Applications of 2 quarts of 0.5% Ciodrin and 1 pint of 2% Ciodrin provided 14-95 days control in dry central Texas and 11-12 days control in humid east Texas. Tests were conducted with several materials applied in minimal amounts by an automatic mist sprayer. Daily applications of 0.2% or 0.5% of DDVP provided excellent immediate control and kept animals entirely free of horn flies. Spraying on alternate days kept populations at a sub-annoying level. Similar results were obtained by spraying daily with 0.125-0.25% Ciodrin. Single applications of 0.5, 0.75, and 1.0% Ciodrin provided effective control for 10, 14, and 14 days, respectively.

In Mississippi, sprays of 0.5 or 1.0% malathion applied at the rate of one-half pint per head provided excellent control for 4 days and satisfactory control for about a week. Similar applications of 0.5% Cygon, methoxychlor, toxaphene and Famophos were effective for 3, 4-5, 4-5, and 5-6 days, respectively. Applications of 2 quarts per animal of 0.5% toxaphene or Co-ral provided effective control for 3-5 and 11 days, respectively. In tests with automatic sprayers, applications of 6 ounces (3 round trips per animal) in one day of 0.1% Baytex, 0.15% Delnav, 0.5% malathion, 0.5% toxaphene, 0.5% Bayer 22408, 1.0% Ciodrin, and 1.0% Ciodrin plus 0.25% DDVP provided effective control for 5-6 days. Ronnel and Baytex at 0.5% were effective 3-4 days. Similar applications of 0.1% Baytex, 0.5% Cygon and 0.5% Bayer 22408 were effective 1-2 days.

In Nebraska, 2 quart applications of 0.1 and 0.25% Stauffer R-1504 (ENT-25705) gave good control of horn flies for 11 days.



4. House Flies. Research was continued at Orlando, Fla., to develop more effective insecticides and other methods and materials for the control of house flies. Twenty-three new compounds were tested as space sprays in a wind tunnel against the regular susceptible colony and the Cradson (multiresistant) colony. Fourteen of the compounds were more effective against both the susceptible and resistant colonies than the standard, malathion. New insecticides were also evaluated as residual treatments against female house flies from the regular or Cradson colonies. The criterion of effectiveness was the number of weeks of aging during which the residues remained effective in killing house fly females. Against susceptible house flies Hercules AC-5727 alone and Bayer 39007 alone gave kills of 90% for one week, but in combination with Monsanto CP-16226, their effective periods were extended to 8 weeks and 12 weeks, respectively. The effectiveness of Hercules 7522H was also extended from 1 to 12 weeks with the addition of Monsanto CP-16226. Against flies of the Cradson colony all of these formulations failed before the fourth week. Against the regular colony Bayer 29952 and Bayer 30237 were effective for 64 and 56 weeks. Stauffer N-2230 and Stauffer N-2404 were 100% effective throughout 48 weeks of aging against the susceptible colony, but they were ineffective against the Cradson colony. General Chemical GC-3583 was still 100% effective after 96 weeks against the regular colony and Monsanto CP-40294 was effective for 24 weeks against the Cradson colony. Against house flies from the susceptible colony, General Chemical GC-4072 was 100% effective for 96 weeks as an acetone solution and Stauffer N-2310, Bayer 39197 and Monsanto CP-40273 for 48+ weeks. As wettable powder DDT was more than 90% effective for 48 weeks, Bayer 25141 for 48 weeks, Bayer 34098 for 40 weeks, Hooker HRS-1422 for 32 weeks, and Bayer 32651 for 28 weeks.

Residual tests (deposits of 100 mg./sq. ft.) were conducted with emulsions of diazinon, Baytex, and dimethoate against house flies in Florida dairy barns. The diazinon treatment failed to give satisfactory control as early as the first day after treatment. Baytex gave 97% control of 5 days and from 79 to 88% control through 14 days. Dimethoate gave controls ranging from 80 to 96% for 6 weeks, when the test was discontinued.

At Corvallis, Oreg., extensive studies were continued on the development of synergists that have been shown to overcome resistance to organophosphorus insecticides in both house flies and mosquitoes. Of some new types of compounds screened, results indicate that diisopropyl or dibutyl

substitutes would be most satisfactory. Selection of house flies with combinations of malathion and synergists are being carried out to determine if resistance to the combinations can be developed.

5. Horse Flies and Deer Flies. In Mississippi tests were conducted to determine the effectiveness of synergized pyrethrum dusts containing 0.1 and 0.067% pyrethrins. Both formulations gave excellent protection from horse flies the day of treatment and fair protection for several days. Mist spray applications of 2 ounces of activated pyrethrum containing 0.62% pyrethrins were highly repellent to horse flies for 6 hours. Lower concentrations were proportionally less effective. Similar applications of 5% ENT-21195 provided complete protection for 6 hours and afforded 79% protection after 24 hours.

6. Lice. In field tests in Mississippi, eradication of cattle louse infestations was achieved with a single spraying of 0.5% General Chemical 4072 and 1% Sevin. Similar results against hog lice were obtained with sprays of 0.1 and 0.25% of GC 4072, 0.5 and 1.0% of Sevin, 0.25% of Ciodrin and 0.5% of Ciodrin, Dilan, and methoxychlor.

7. Ticks. Research on the control of ticks was confined to the Texas laboratory. Only 5 of 79 compounds screened for systemic effectiveness showed systemic action against lone star ticks engorging on treated guinea pigs. The effective materials, dosages (mg./kg.) and routes of administration were as follows: Monsanto CP-19203, 10 mg. O; Hercules 7845 and Stauffer R6032, 50 mg. O and SC; Shell 8280, 50 mg. SC; and Shell 8530, 100 mg. O.

In field tests, sprays of 0.5% toxaphene and 0.25% Stauffer 1504 gave excellent control of lone star ticks on cattle and were slightly better in both immediate and residual effectiveness than 0.025% diazinon, 0.05% carbophenothion, 0.1% Ciodrin and 0.25% Sevin and Dilan. In tests against the winter tick, complete control was obtained with sprays of 0.05% carbophenothion, 0.25% Bayer 37341, 0.1% Dipterex, 0.25% Dowco 175, and 0.3% Ciodrin. Diazinon at 0.05% gave excellent but incomplete control.

### C. Biological Control

1. Mosquitoes. At Fresno, Calif., in cooperation with the Bureau of Vector Control, California State Board of Health, studies were initiated on the biological control of mosquitoes. Several species of microsporidia of the genus Thelohania killed mosquito larvae. Studies are under way to determine the host-parasite relationship.

2. Stable Fly and House Fly. Spalangia muscidarum, a pupal parasite that attacks stable flies, house flies and other Diptera, was reared in sufficient numbers in the laboratory at Lincoln, Nebr., to permit the start of systematic releases on May 16. An area of 16 square miles containing 20 farms was selected as a release area and 5 farms at another location were used for control observations. The release rate was varied from farm to farm according to the extent of the potential fly breeding areas. The release of this parasite, plus the natural occurrence of



several other parasites, failed to produce marked reductions in stable fly or house fly populations. The percentage parasitism of pupae was erratic but at times very high. In general, planted pupae were more heavily parasitized than naturally occurring pupae. The percentage parasitism ranged from 0 to 100, without any apparent correlation with either time of year or the number of parasites released. In the course of these studies it was determined that three parasites parasitize stable fly pupae only, four parasitize both stable fly and house fly pupae, and four parasitize house fly pupae only.

#### D. Insect Sterility, Attractants and Other New Approaches to Control

1. Mosquitoes. In Oregon tepa and ENT-50450 were tested as sterilants against Culex tarsalis adults by spraying in wind tunnel tests and against larvae by exposure in water. Tapa sterilized males and females at a spray concentration of 6%; ENT-50450 sterilized only males at this concentration. Lower concentrations of either compound were not effective. Against larvae, both compounds were toxic at higher test concentrations and ineffective and partial toxicants at lower concentrations.

In Oregon studies have shown that grass infusion and log pond waters are attractive to ovipositing female Culex pipiens quinquefasciatus. Distilled water treated with methane or furfural was more attractive to ovipositing females than distilled water, but less attractive than log pond water.

2. Stable Fly. In Texas a small number of chemicals was evaluated by several methods as chemosterilants against the stable fly. Topical applications of 1.0 ug of ENT-26382 sterilized both sexes of flies. Similar applications of 4 ug of ENT-50569 sterilized males but did not completely sterilize the females. Three other materials--ENT-50042, 50396 and 50549--at 4 ug per fly, reduced oviposition and hatch but did not fully sterilize either sex.

In feeding tests, flies were completely sterilized when fed baits containing 0.2% aphoxide for 24 hours. Flies fed 0.1% aphoxide bait produced normal numbers of eggs but only 2% hatched. Several materials were tested as residual treatments but none of them produced complete sterility.

Studies were conducted to determine the absorption, metabolism, and excretion of a  $P^{32}$ -labeled chemosterilant (MAPO) applied topically and in the diet of stable flies. When applied topically, the material was rapidly absorbed, with the females showing maximum absorption in 6 hours and the males in slightly longer time. The material was metabolized to the extent of about 60% in 24 hours. The main metabolic products were phosphoric acid and an unknown intermediate. Four other metabolites were isolated but not identified.



In the feeding tests MAPO was absorbed and distributed slower and in lesser amounts than in the topical tests. After 24 hours the degree of metabolism was about 50% higher than in the topical tests. In contrast to the topical tests, the main metabolite was an unknown intermediate which was about 4 times as abundant as phosphoric acid. Three of four other unknown intermediates occurred in greater amounts than phosphoric acid. Only about 8% of the applied dose of MAPO was excreted.

3. Horn Fly. In Texas horn flies were sterilized by feeding overnight on a bait containing 0.05% tepa but a concentration of 0.01% was ineffective. Topical applications of 0.1 ug/fly fully sterilized both sexes of flies.

In Oregon adult horn flies were sterilized by exposing the pupae to 5000 r.

4. Screw-worm. In Texas where studies with the screw-worm were conducted, 57 of 350 compounds screened as candidate chemosterilants caused sterility when administered as topical treatments or fed to adults. Some of the compounds sterilized by both methods of administration. Secondary tests showed that some of these compounds sterilized one or both sexes completely, while others induced only partial sterilization or were ineffective. Tests with tretamine applied topically showed that adult flies could be sterilized when they were 1, 3, and 5 days old with equal facility. Males sterilized with thiotepa survived as well as untreated flies and competed equally with untreated males in mating with females. However, the treated males were not as sexually competitive as untreated males. When a single dose of thiotepa or tretamine, adequate to sterilize either sex, was given in two half-doses 24 hours apart, survival of the flies was not improved and, further, a loss in sterilizing effectiveness occurred. Tretamine and thiotepa completely or partially sterilized screw-worms when puparia were immersed in solutions containing these compounds or were injected with them. With immersion, washing of puparia decreased the sterilizing effect indicating that adults obtained some or most of the sterilizing dose as they emerged from the puparium. Aerosol treatment of screw-worm adults with tretamine resulted in almost complete sterility.

Preliminary laboratory experiments indicated that ENT-50450 was as effective as gamma radiation in sterilizing screw-worm flies, and was superior in its lack of toxic side effects. Females mated to males sterilized with ENT-50450 continued to lay infertile eggs after the initial deposition of eggs indicating that sperm in spermathecae of females did not recover fertility. Males sterilized with ENT-50450 remained sterile throughout their lifetime.

Investigations with screw-worm flies and aziridinyl-type chemosterilants resulted in the conclusion that the primary influence of aziridinyl compounds on the ovaries of flies 0-4 hours old is the inhibition of oogenesis, and of flies 1 day old, the induction of mutations. The effects of the aziridinyl compounds on the reproductive potential of female screw-worm flies were similar to those obtained with gamma radiation.



Studies were conducted to determine the absorption, metabolism and excretion of a  $P^{32}$ -labeled chemosterilant (MAPO) applied topically and in the diet of screw-worm flies. When applied topically the material was absorbed rather gradually. The absorbed material was metabolized to the extent of 42 and 58% in males and females, respectively, in 24 hours. The principal metabolic products were phosphoric acid and an unknown intermediate. Small amounts of five other intermediates were indicated but were not identified.

In the feeding tests, metepa was absorbed and distributed at about the same rates as in the topical tests. After 24 hours, the degree of metabolism in females was about the same as that in the topical test but, in the males, metabolism was 50% higher than in the topical tests. As in the feeding tests, the main metabolic products were phosphoric acid and an unknown intermediate. Five other intermediates were isolated but not identified. Approximately one-fifth of the applied dose of metepa was excreted.

Approximately 200 chemicals and other materials were screened as attractants for screw-worm flies. Of these, 10 were equal to or better than the standard liver bait and require further evaluation. Preliminary studies have indicated that mutant strains of screw-worm flies may respond differently from normal strains to attractants since black-mutant flies were not attracted to the standard liver bait.

5. House Flies. Research on the development of sterilization for the control or eradication of house flies has been continued in Florida and Oregon. In Florida 886 new chemicals were screened for sterilant activity. Of these some produced toxic effects; however, 90 caused complete or partial sterility in the treated house flies. Seven compounds were highly effective in sterilizing both sexes of house flies, but two of these were also toxic at the dosages tested. Metepa and tepa as residual deposits on glass sterilized house flies at dosages from 25 to 250 mg. per sq. ft., but 5-fluoroorotic acid was ineffective as a residual deposit at similar dosages. Apholate in the adult food sterilized house flies regardless of their age and the flies did not regain fertility. Motile sperm were present in the testes of chemosterilized males and transferred during copulation to the spermathecae of females throughout the life span of the male.

Tests were initiated in Florida to determine whether a dosage of chemosterilant too low to prevent hatching or adult emergence might by the accumulation of small genetic injuries eventually reduce or eliminate reproduction. With apholate, one colony showed reduction of oviposition in the 4th, 5th, 6th, and 7th generations and no individuals reached the pupal stage in the 7th generation. With metepa, the 5th through 9th generation of another colony showed reduced oviposition and the 10th generation failed to oviposit.

Preliminary tests with apholate, tepa, and metepa, on house flies indicated that the probit of the percent sterility with house flies can be related to the log of the concentration.

Metepa and apholate shortened the life span of adult house flies considerably, but 90% or more of the male population survived the first 10 days, or that period of time in which mating activity is the greatest. Survival during the first 10 days was essentially the same in treated and non-treated house flies. Dipping house fly pupae in solutions of tepa, apholate, or metepa was toxic to most individuals, but a high degree of sterility occurred in individuals surviving the treatment.

Effective formulations of both dry baits and paint-on liquid baits have been developed.

A method has been devised for studying chromosomes of house flies. Using this technique, the effect of chemosterilants on spermatogenesis and oogenesis will be made.

Studies conducted in Oregon with an olfactometer and with simulated treated fly models (pseudo flies) demonstrated the presence in female house flies of a volatile chemical or chemicals which can influence the behavior of male flies. The behavior modification elicited was in the nature of attraction to a source of the pheromone, or an excitation of mating behavior patterns. The material which is benzene soluble and relatively stable was shown to be sex related, and appeared to be specific to the house fly since extracts of neither the face fly or stable fly affected the behavior of male house flies.

In Oregon tests were conducted to determine sterilizing effects of tepa and metepa on the little house fly (*Fannia canicularis*). All flies feeding on bait containing 0.1% tepa for 4 days and 0.5% tepa for 2 days succumbed in 3 and 5 days, respectively, and none oviposited before death. Flies feeding on 0.05% tepa for 3 days survived normally but did not oviposit. Metepa at 0.5% was highly toxic to flies. Flies feeding on baits containing 0.05 and 0.1% metepa survived and laid a few eggs but none hatched. Longevity of flies exposed for 2 hours on 100 mg. per sq. ft. residues of tepa was greatly reduced and all flies so treated were fully sterilized. Flies exposed on residues of 1 and 10 mg./sq. ft. laid a few eggs but none hatched. These tests indicate that the little house fly is much more easily sterilized than the house fly.

Over 50 inorganic and organic materials were tested as attractants for the little house fly. None showed significant attractancy.



In cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions, studies were continued in new facilities at Beltsville, Md., to develop physical and mechanical methods of controlling house flies and other flies affecting cattle. Colonies of flies were established for conducting laboratory and outdoor cage studies. Studies to date have been concerned primarily with the attractiveness of various flies to different kinds and intensities of light. Black light ultraviolet radiation was attractive to both house flies and face flies during twilight periods. The use of fluorescent panels behind light sources increased their attractiveness.

6. Ticks. Extensive tests were conducted in Texas to determine the effects of different levels of radiation on different stages of the lone star tick. One series of tests with nymphs which had been engorged 2 weeks were exposed to different levels of radiation and the adults subsequently placed on hosts. Adults from nymphs exposed to 500 r or 1000 r engorged but produced no eggs. At a dose of 2500 r adults engorged normally and treated females mated with treated males did not oviposit. One of 8 treated females mated with normal males oviposited and some of the eggs hatched. When females and males treated with 5000 r were confined on hosts neither sex engorged. Similar results were obtained with untreated males and treated females, but when treated males and untreated females were used, 2 of 3 females engorged and oviposited. One of the two egg masses obtained was not viable and the other showed only a partial hatch.

Exposure of newly emerged adult ticks to 1000 r and 2500 r did not affect engorgement and complete sterility was indicated in crosses of treated males and females and in crosses of untreated males and treated females. Untreated females mated with treated males produced eggs but none hatched. One of the ticks exposed to 5000 r engorged but it did not oviposit. No ticks engorged after treatment with dosages of 7500 r or 10,000 r.

Some of adult ticks dipped in concentrations of 0.25 and 0.5% of apholate, tepa, metepa, or tretamine were killed but those that survived engorged and laid viable eggs. Dipping in 1% concentrations of these materials also failed to produce complete sterility but the maximum viability of eggs from females treated with apholate was only 0.25%.

#### E. Evaluation of Equipment for Insect Detection and Control

1. In Texas, in cooperation with the Agricultural Engineering Research Division, studies were undertaken to develop control mechanisms for automatic spraying devices that would be stable and dependable and which would not excite cattle. Step-on electric switches (switch-mats) installed on the ground underneath the spray nozzles were superior to the usual electric eye switches. The step-on switches provided quick and reliable operation of sprayers and required only limited maintenance. Cattle were

not aware of the imperceptible movement when they stepped on the mat and activated the sprayer. Most of the commercially-available automatic sprayers have mechanical defects and several adaptations were tried as improvements. One adaptation of the ring-type fitted with 7 nozzles proved superior to the commercial types.

At Beltsville, Md., in cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions, work was initiated to develop test equipment and techniques of operation to evaluate the attractiveness of visible and ultraviolet radiation to house flies or other flies affecting cattle. This research has not yet reached a point of profitable summation.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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EQUIPMENT AND BUILDINGS USED IN PRODUCING SWINE  
Agricultural Research Engineering Division, ARS

Problem. The American farmer has about \$14 billion invested in service buildings and related structural equipment, over half of it for livestock facilities. Maintenance and new construction amount to another \$1.2 billion annually, again mostly for livestock facilities.

Economic conditions are forcing changes in the pattern of livestock production. Producers are trending toward fewer, larger and more specialized enterprises and toward "confinement" types of facilities in their effort to reduce production costs and improve product quality. These trends are demanding more basic knowledge on the effects of environment on the health, growth, production and fertility of livestock; on structures and related equipment for maintaining optimum environments; and on methods, structures and equipment for more efficient handling and feeding. The continuing threat of nuclear warfare demands consideration of types of buildings that could provide protection from fallout for livestock and their feeds, and provide facilities for operation during periods of emergency.

Much more needs to be learned in the laboratory on the relationships between livestock environment and disease transmission, feed conversion rates, and growth and production in order to determine optimum environments. Structures and equipment for economically providing these optimum environments under practical conditions need to be developed and field tested. Closely associated with the environment are flies and other insects, as well as parasites and diseases, that sap the vitality of animals and reduce their productivity. Pesticide residues in animal products are causing much concern. Information is needed on means for keeping these residues from adversely affecting the animals or their products.

Labor also is an important element in overall production costs, and if only family labor is available, the labor requirement limits the size of enterprise. How to adapt existing buildings and other facilities for more efficient production, as herds and flocks are increased in size, or as farms are consolidated, is a major problem area. Cost of replacement or major improvement of existing buildings that are not suited to modern production methods are serious obstacles. Principles, examples and techniques for planning more efficient operations are needed both by farmers doing their own engineering and by those on whom farmers depend for advice.

Today's technology in farming requires accurate instruments for measuring or monitoring processes such as grain and forage drying and plant and animal environment. Some problems require completely new kinds of instruments. Studies are necessary to determine the accuracy and practicability of instruments for many kinds of agricultural instruments.



## USDA PROGRAM

Research pertaining to livestock engineering is a continuing program involving engineers and architects conducting basic laboratory investigations, application of laboratory results to a production basis, and development of typical plans for livestock structures. The work is in cooperation with the AH, ADP, and ENT Divisions of ARS, USDA, and State Agricultural Experiment Stations, and contributes to Cooperative Regional Projects NC-23, "Farm Structures to Meet Environmental Requirements of Dairy Cattle, Swine, and Poultry." Plan development work is cooperative with all the State Agricultural Experiment Stations and Extension Services.

Federal research in the area of livestock engineering totals 9.1 professional man-years. Of this number 2.2 is devoted to dairy; 0.3 to beef; 1.3 to swine; 3.2 to poultry; 0.1 to shades and shelters; 0.2 to sky radio-sity studies; 1.0 to reducing pesticide residues in animal products; and 0.8 to program leadership.

Federal research in the area of electric equipment for farm labor reduction involves 5.0 professional man-years of which 2.5 are devoted to livestock and poultry; and in the area of electric and solar equipment for environmental control involving 5.9 Federal professional man-years, 0.2 are devoted to swine.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Swine Engineering

1. Effect of humidity on swine. At Davis, Calif., in cooperation with the California Station, the effect of humidity on swine is being investigated in three chambers, each with 20 sq. ft. of floor space, built into a psychrometric chamber. Temperature and humidity of each can be controlled. These are basically insulated wood boxes with wire mesh floors. Air is introduced through separate humidifying chambers to plenum chambers above each house. Air is discharged from each house via the floor. Each house has a 2-hole self-feeder and automatic watering cup. On February 20, four cross-bred pigs (2 barrows and 2 gilts) were placed in each house. They were born January 8, 1963, and weighed 20 pounds each at the start of the test. One group will be kept at a constant temperature-humidity index, THI (73° F. dry bulb and 88° F. dew point) to market weight. A second group will be started at this same THI (this is theoretically optimum THI for this size pig) and the THI will be adjusted downward by hog weight so as to maintain these pigs always at the same optimum THI. The third will be given the opposite treatment so they will be under stressing conditions at all times. This is the first of a series of tests designed to determine the effects of humidity on weight gain, health, and feed conversion of swine.

2. Hot, arid climate. At Davis, Calif., in cooperation with the California Station, studies of sprinkler operation continued in a program designed to determine the best types of nozzles and methods of operating them for maximum effectiveness in cooling swine. Four outside pens of 10 Duroc pigs each were equipped with various kinds of sprinklers that were operating for different periods between 10 a.m. and 8 p.m. Each pen had two Monarch F-110 nozzles operating as follows:

No. 6.4	2-1/2 minutes out of 15
No. 6.4	15 minutes out of 30
No. 6.4	Continuously
No. 2.0	Continuously

The daily gains of pigs with continuous sprays (No. 6.4 nozzles) were greater than all others except for those with sprays on 1/2-time (5% level). There were no differences in gains among the 1/6-time, 1/2-time and continuous fine sprays (No. 2.0). Feed conversion rates could not be tested statistically because the animals were group fed; however, in terms of actual feed conversion rates there does appear to be some advantage in using sprays operating half-time, particularly if supply or drainage of water is a problem. The daily rates of water used by each pen were: 1/6-time, 15 gallons; 1/5-time, 50 gallons; continuous, 100 gallons; and continuous fine spray, 32 gallons.

Tests of air conditioned houses for swine were continued at El Centro, Calif., in cooperation with the California Station. The first test was reported last year. Two air conditioned houses 6' x 14' x 4-1/2' were used to house 8 cross-bred hogs in each. Inside air temperature was maintained at about 70° F. These houses were identical except a feeder and waterer were placed inside in one house and outside of the other. The second house had a dummy feeder so floor space was not a variable. A control group of pigs had access to a shaded wallow. Analysis of the two years of data indicate no significant differences in daily gain, carcass yield, or backfat thickness that could be attributed to air conditioning. However, each year the air conditioned hogs gained 0.1 lb. more per day than animals with access to shaded wallow. Placing feed and water inside the house had no effect on gains. Feed consumption was significantly greater when the feeder was inside the house, although feed utilization was not superior for this treatment. This test will be repeated a third year.

3. Hot, humid climate. The value of shade and shade plus fogging for growing-finishing pigs in hot, humid climates was studied at Tifton, Ga., in cooperation with the Georgia Station. A movable shade (12'x16') on skids was designed for this study, in which 32 pigs (avg. 61.6 lb. each) were held in small pasture lots (8 pigs per lot), two lots had shade plus fogging under the shade and two lots had shade only. Since two rations were fed, no conclusions of significance could be drawn from this first year's data, but there was a trend to benefit from sprinkling as far as weight gains were concerned. This test will be repeated.



The value of shade and shade plus fogging for gestating sows and gilts in a hot, humid climate was also studied at Tifton. A movable shade (12'x16') on skids was designed for this study, in which 16 sows and 16 gilts were in temporary pasture lots (8 animals per lot), two lots had shade plus fogging under the shade and two lots had shade only. Average rectal temperatures and respirations per minute for the animals having access to the shade and fogging were 101.2° and 60.6, respectively, while the same measurements for the animals having shade only were 103.0° and 143.3, respectively. However, the average number of live pigs farrowed, birth weight of live pigs, number of pigs weaned, and adjusted 56-day weight of pigs were essentially equal for the two treatments. This is only one year's data and it is estimated that three to four years' data will be required for analysis.

4. Type of housing - level of feeding. At Escalon, Calif., studies on type of housing and level of feeding of swine were continued in cooperation with a major hog producer. Two replicates were reported last year. The third and final replicate is included in the data presented here. The three replicates provide a year-around representation of the data. These were as follows:

	<u>No. Pens</u>	<u>Pigs/Pen</u>	<u>Level of Feed, %</u>
March 30 - June 13, 1961	12	10	63, 71, 78, 86
July 21 - October 16, 1961	9	10	71, 78, 86
January 4 - March 26, 1963	9	10	71, 78, 86

The levels of feed were based on certain percentages of those recommended on the basis of live weight by the National Research Council. The three types of housing were (a) a totally enclosed insulated building, (b) an extension of this building, but without sidewalls, and (c) an open shed with a concrete floor. Differences in gains in weight due to differences in housing and feeding levels were both highly significant (1%). Hogs fed in the outside shed (11 sq. ft. per pig in all pens) gained weight slower and required more feed per unit of gain than in the totally or partially enclosed houses. Pigs in the outside pens also had lower specific gravities and therefore were less lean. Feed per unit of gain was significantly higher for the 86% feeding level than the 78 or 71% levels. Feed conversion was greatest in the spring and lowest in the winter. Four hogs from each group in each replicate were slaughtered and their specific gravity measured.

5. Stand-up feeding. In cooperation with the California Station, stand-up feeding of pigs was investigated at Davis as a means of improving the commercial carcass cuts of swine. Feeders were designed so that pigs would stand on their hind legs to eat. The purpose was to determine if this type of exercise affected commercial pack cuts. In the first test, started January 8, 1962, four groups of six Duroc barrows weighing 120 pounds were randomly assigned, two groups to the standing treatments and two groups fed in ground-level troughs. They were fed for 49 days this way. Carcass studies indicated no significant differences between treatments as to yield, carcass length, backfat thickness, eye muscle area of the tenth rib cut, carcass specific gravity, and percentage of the loin, shoulder, or belly of the carcass. Backfat thickness, eye muscle area and specific gravity favored the standing pigs. The percentages of ham, or ham and loin, were greater in the standing pigs. A second trial was conducted between June 7 and October 1, 1962. Three pens were used with 11 pigs per pen weighing initially 60 to 70 pounds each. Two groups were fed in ground-level troughs, one free choice and the other restricted (twice daily) to the amount of feed consumed by the stand-up pigs. The third pen had two 6-ft. long stand-up troughs. New troughs, each 7-ft. long, were constructed and installed on August 7. One day of every other week a 12-hour activity check was made from 7 a.m. to 7 p.m. These data have not been completely analyzed, but the results were generally the same as the first group with the percent loin being greater in the standing pigs. This test will be repeated.

6. Slatted floors. Work has been initiated in cooperation with the Minnesota Northeast Experiment Station at Duluth, Minnesota, to study the use of slat floors as compared with the open, solid concrete feeding floor. In this study the labor requirements, production performance and slat materials (including wood, concrete and steel) are being observed.

7. Plan development. Based on the research at Tifton, Ga., a plan for a portable shade for hogs was developed for the Cooperative Farm Building Plan Exchange.

## B. Electric Equipment

Tests are currently being conducted in cooperation with the University of Illinois Agricultural Engineering Department and the Animal Science Department to evaluate the quantity of air needed and effect of the point of entry of fresh air into a confinement hog raising building. These tests are not complete at this time. Time controlled and time limited hog feeding studies were disrupted by street construction work and no report is available this year.



### C. Equipment for Swine Environmental Studies

In cooperation with the Virginia Agricultural Experiment Station hogs were grown in controlled environment from weaning to market weight utilizing heat pumps with approximately 3 to 1 electric energy conversion efficiency. There were no significant differences in gain per day or feed efficiency between the temperature controlled house and the conventional house.

In cooperative work in California, final analysis of data collected during a study reported last year, relating electrical energy consumption for air-conditioned livestock shelters to cooling indices, provided useful information for predicting operating costs. Cooling degree-days calculated from the mean daily dry-bulb temperature gave satisfactory correlations with energy use (by regression analysis), and have an additional advantage of being easily computed from readily available data. By combining all air-conditioning units used in the four separate studies on the basis of kilowatt-hours used per compressor horsepower and relating to cooling degree-days computed from mean daily dry-bulb temperatures, very good correlation was obtained ( $r = 0.775$ ). The prediction equation obtained for energy use can tentatively be extended to cover possible applications to other types and sizes of air-conditioned farm buildings. The California Agricultural Experiment Station Department of Agricultural Engineering was an active cooperator in the livestock shelter air-conditioning study.

In continued ionization studies, three ion houses 8 x 5 x 4 feet were installed in the hog barn. Air for each house was introduced through a side wall, past ion generating equipment, and exhausted through the wire mesh floor. The air in each house had a different ion treatment, excess positive ions, excess negative ions, or natural conditions. Two tests were completed (a) May 29 to August 20 with pigs starting at about 62 pounds and ending at about 170 pounds, and (b) December 18 to March 6 with hog weights of about 80 pounds to 200 pounds. There were four Duroc pigs per house. The data from neither of these tests has been analyzed but there appear to be little, if any, effects from the treatments.

### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

#### Swine Engineering

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- Bond, T. E. 1963. Summer comfort with water. Proc. Animal Husbandry Swine Day, Davis, California, pp. 5-13.
- Bond, T. E. 1963. Swine environmental research in California. Presented at Pacific Coast Section, ASAE, San Francisco, California as Paper No. P.C. 63-9.
- Bond, T. E. 1963. New results from farm animal environment studies. Presented before Pacific Coast Section, ASAE, San Francisco, California as Paper No. P.C. 63-12.

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- Garrett, W. N. 1963. Effects of experimental environments on fattening swine in a hot climate. Proc. Animal Husbandry Swine Day, Davis, California, pp. 15-23.
- Heitman, H., and Moore, H. A. 1963. Type of housing and level of feeding for swine raised in confinement. Proc. Animal Husbandry Swine Day, Davis, California, pp. 25-34.

#### Hog Equipment

- Puckett, H. B., and Olver, E. F. 1962. The role of controls in an automated agriculture. Presented at the Farmstead Planning and Mechanization Workshop, University of Illinois, Urbana, Illinois.

#### Equipment for Swine Environmental Studies

- Hahn, L.; Bond, T. E. and Kelly, C. F. 1962. The Relation of Cooling Indices to Electrical Energy Consumption of Air Conditioned Farm Structures. ASAE Paper No. 62-933. Presented before American Society Agricultural Engineers, Washington, D. C.



## II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

### NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS  
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

### USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Beltsville, Maryland, and at Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 66.3 man-years. It is estimated that approximately 5.3 man-years is concerned with studies related to pork products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis,

though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 23.4 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to lipids are considered briefly in this report.

## REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

### A. Nutrient Values of Pork

1. Tables of food composition. The 1963 revision of Agricultural Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared," was completed and carried through to the galley proof phase. A major expansion of the number of meats and meat products has been made. Fresh and cured pork items amount to 130. Data for pork are shown with the major classifications on the basis of fatness (fat, medium, and thin) rather than market grade. Data are given for separable lean and separable fat tissue so that these can be combined in any desired proportions for individual needs. This provides a basis for calculating composition values for cuts that vary from the average in retail trimming, and for additional trimming in the home.

Data in the popular publication, "Nutritive Value of Foods," Home and Garden Bulletin No. 72, have been revised to agree on a weight basis with nutritive values in Handbook No. 8. The revised edition will provide nutritive values of household measures of 512 commonly used foods. Another popular publication, "Conserving Nutritive Values in Foods," Home and Garden Bulletin No. 90, is in press.

2. Proximate composition. Proximate composition data have been obtained on the separated portions (lean, subcutaneous fat, intermuscular fat, waste, and drippings) of 48 cured and cooked cured hams representing different degrees of fatness. Similar measurements on cured and uncured hams from comparable carcasses were obtained under contract at the University of Illinois. The data have been prepared for statistical analyses and a technical bulletin will be prepared.

The proximate composition of 38 main dish foods in several market forms--home-prepared, packaged combination, canned, frozen, and chilled--has been determined. These studies were carried out cooperatively with the Fish and Wildlife Service, U.S. Department of the Interior. Plain meats, frozen dinners, sandwiches, pies, fried breaded foods and combination dishes were included in this study. Caloric values calculated for sandwiches, pies, and fried breaded foods were high and tended to follow fat content. Protein content ranged from 5 percent or less in spaghetti and commercial chow meins to more than 15 percent in most plain meats and fried breaded foods.

Commercially prepared foods generally had lower fat, protein, and caloric values, and higher ash and carbohydrate contents than did corresponding home-prepared foods. Composition values for most forms of foods were



remarkably consistent among the lots analysed. The results have been summarized and a technical bulletin prepared for publication.

3. Lipids. The fatty acid composition of selected food fats has been determined using gas-liquid chromatography for separation of fatty acid esters. A manuscript was prepared presenting procedures of extraction resulting in minimal alteration in fatty acid composition. Linoleic acid (18:2) comprised 8 to 9 percent of the total fatty acids in lards, 6.8 percent in mixed pork and beef shortening, and 8 percent in ham covering fat; linolenic acid comprised 0.6 to 1.2 percent in lards, 1.0 percent in mixed pork and beef shortening and 0.9 percent in ham covering fat.

Lipid biosynthesis is being studied as a possible criterion for assessing the nutritional value of foods. Rats developed acute deficiency symptoms when fed a cholesterol-free diet plus an inhibitor of cholesterol biosynthesis. The content of total sterols in their carcasses and tissues was about the same as for control animals fed a cholesterol-free diet. Analysis of the major sterols by Entomology Research Division showed 75 percent of the total sterols to be desmosterol and less than 20 percent to be cholesterol in the carcasses of the inhibitor-fed rats; in the carcasses of control rats 95 percent of the total sterols was found to be cholesterol. A manuscript presenting these findings has been accepted for publication. In other phases of this research, lipid biosynthesis in relation to age and diet is being investigated.

4. Proteins and amino acids. A manuscript was published describing a method for assay of alanine using Leuconostoc citrovorum 8081 and reporting results of analysis of 48 proteins and foods, including pork loin and ham which contained respectively 0.362 and 0.737 grams of alanine per gram of nitrogen.

5. Mineral elements. The content of mineral elements was determined in composite samples of separable lean, cover fat, intermuscular fat, and waste from paired hams, cured and cooked cured, including drippings from the cooked hams. The data are being summarized and a manuscript will be prepared on the effect of roasting or baking upon the mineral element composition of cured hams. The hams were obtained as part of a research contract with the University of Illinois.

6. Vitamins. Analyses for niacin, riboflavin, and thiamine have been completed on samples of separable lean from 24 paired fresh and cured hams. The results will be prepared for publication.

An improved method for thiamine determination has been developed. The conditions of the 6-aminothymol colorimetric reaction were changed so that a stable fluorescent compound was produced with thiamine. The fluorescence made possible measurements at much lower concentrations and appeared to be simpler than the usual thichrome reaction.

Research continued on procedures useful for B-vitamin analyses to permit characterization of B-vitamins in foods and their overall distribution in



the food supply. A procedure has been developed for the quantitative determination of pyridoxine (vitamin B<sub>6</sub>) as pyridoxal cyanohydrin. Studies will be continued to apply this chemical procedure to the assay of vitamin B<sub>6</sub> in food extracts and to verify results by comparisons with those of the microbiological assay.

## B. Properties Related to Quality and Consumer Use of Pork

1. Quality of pork hams, uncured and cured. Color, juiciness, and flavor characteristics of the lean meat from cooked and uncooked cured hams were evaluated as both warm and cold samples. The hams came from carcasses selected for low, medium, and high thickness of subcutaneous fat and low and high marbling levels. A manuscript is in preparation on this part of the research.

Data on the yield of separable lean, cover fat, intermuscular fat, skin and bone determined at Beltsville for 24 pairs of cooked and uncooked cured hams and similar data for 24 pairs of fresh and cured hams determined under contract at the University of Illinois are being analyzed. Manuscripts are being prepared.

2. Pork sausage storage. Studies are in progress on the use of an anti-oxidant combination upon maintenance of palatability of pork sausage links during refrigerator and freezer storage. Pork sausage links made with and without butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) and frozen immediately after processing are being evaluated for palatability 11 days after processing (comparable to normal marketing period), and after refrigerator (45° F.) and freezer (0° F.) storage intervals selected as representative of household practice. This work is cooperative with the Meat Inspection Division.

3. Fresh, frozen, canned pork products. The preparation time, serving yield, food components, and quality characteristics for home-prepared and purchased chilled, frozen, and canned pork products were determined. Results have been summarized for publication as a Department bulletin along with similar data on beef, poultry, cheese, and fish items. Fully cooked, chilled hams and cook-before-eating hams required only 2 to 3 minutes active preparation time and each took about 3 hours total preparation time. Canned and frozen pork sausage required 4 to 5 minutes active preparation time and 5 to 17 minutes total preparation time. Lean meat content of cooked ham with bone was 48 percent for cook-before-eating ham and 49 percent for fully cooked, chilled ham. After heating, boneless canned ham had 62 percent lean meat content. Home-prepared pork sausage patties after cooking retained 47 percent and links 45 percent of their initial weight. Canned sausage retained 55 percent and frozen sausage 81 percent of their purchased weight.

4. Freeze-dried meat products. Freeze-dried meat products were evaluated for general acceptability, appearance, flavor, juiciness, texture or consistency, and tenderness in cooperation with the Marketing Economics Division, Economic Research Service. The object was to provide information on which to



base estimates of consumer acceptability of freeze-dried products in retail, institutional, and manufacturing markets, and suitability of these foods for specialized uses such as emergency rations, catering, and armed services use. Food products included in a comparative study of freeze-dried foods and other processed forms of the same food were ranch-style breakfast (sausage and eggs), diced ham, and pork chops. Either frozen or canned processed products were selected for comparison with the freeze-dried foods whenever possible. Fresh products were selected only if a processed one was not available on the local retail market.

All of the freeze-dried foods were considered acceptable in quality. Freeze-dried pork chops and diced ham were most palatable of all freeze-dried meat products; however, they were not as good as frozen pork chops or canned ham. The general acceptability of sausage from the ranch-style breakfast was fair to good. The freeze-dried products given low scores were weak or lacking in flavor or off-flavored, fibrous, stringy, powdery, mealy or woody in texture, and tough and chewy in tenderness. Results of these studies are published in a marketing research report.

5. Shortening properties of fats. Investigation of the shortening properties of five kinds of fat--corn oil margarine, hydrogenated vegetable fat, hydrogenated vegetable and animal fat, regular margarine, and butter at different levels of added fat, liquid, and sugar in white cakes is in progress. Sensory, physical, and chemical measurements are being used to determine the influence of the proportion and kind of fat on the quality of the baked product. A report on levels of fats and oils in pastry and biscuits was accepted for publication in Cereal Chemistry.

Two methods of mixing pastry dough which make high quality pastry with less than the usual amount of fat were developed. One of the mixing methods uses liquid cooking oil, the other uses solid fat. In the oil method water and oil together, both at room temperature, are sprinkled into the dry ingredients while blending with an electric mixer at lowest speed, for 3 minutes. The even distribution obtained by sprinkling the oil and water into the dry ingredients results in a tender, flaky pastry.

Even distribution of fat and water also is responsible for the success of the solid fat method which allows the use of less fat than usual. Room temperature fat is blended into the dry ingredients with an electric mixer at lowest speed for 2 minutes, then water is sprinkled in and blended 1 minute. How-to-do-it instructions were released to the general public.

### C. Nutrient Functions

Lipids. A better understanding of specific relations between diet, health, and longevity has resulted from long-term investigations with laboratory animals fed 29 different experimental diets including two that contained 8 and 16 percent lard. Both excessive food intake and relationship or balance of nutrients in the diet are implicated in the adverse effects that occurred throughout the lifespan of laboratory animals. The studies indicate that genetic strain affects the response to the different diets and thus emphasize



the importance of recognizing inherited characteristics in evaluating response to diets. Survival varied even with diets of similar fat and protein content. Differences in serum cholesterol levels of animals showed no relationship to kind or level of fat nor to level of dietary cholesterol.

Research on the effect of feeding rats, throughout their lifetime, diets containing fresh and oxidized lard, butter, olive and cottonseed oil was carried out under contract in New York City. Structural analyses of triglycerides in the diets and in adipose tissue have shown that rats produced molecular types not present in the dietary fat although the structure of the depot fat was strongly influenced by the dietary fat. Oxidation of the dietary fats exerted only a mild effect on the structure of the depot fat triglycerides.

#### D. Human Metabolism

Manuscripts are being prepared for publication presenting results obtained in contract research at Los Angeles, California, on the effect of the type of dietary protein on the response to variations in dietary linoleic acid and at Lincoln, Nebraska, and Battle Ground, Indiana, on the effect of the amount of dietary protein on the response to a constant amount of dietary linoleic acid.

#### E. Food Consumption and Diet Appraisal

1. Food consumption and dietary levels. A report of the findings of the food consumption survey of beneficiaries of Old Age and Survivors Insurance made in Rochester, New York in the spring of 1957 has been completed. The survey included 283 1- or 2-person households. During the survey week, food brought into the kitchens of these households averaged about the following amounts per person: 4 quarts of whole milk or its equivalent in milk products; 4 pounds of meat, poultry, fish; 1/2 dozen eggs; 10 pounds of vegetables and fruits; 2 pounds of grain products (in terms of flour); 1 pound of sugars and sweets; and 3/4 pound of fats and oils. The total money value of all food per person was \$8.12. Nutrients from this food more than met the National Research Council's recommended allowance for the average person. However, less than half (44 percent) of the households had diets which met in full the recommended amounts for all nine nutrients (good diets). Nearly three-fourths of the households had diets that met two-thirds of the recommendations for all nutrients (good and fair diets). The nutrients which fell below the recommended allowances most often were thiamine and calcium.

The series of food surveys conducted in low-income areas to aid in the study of the effects of food distribution programs on diets of families has been extended to include a survey carried out in Choctaw County, Oklahoma and in Pensacola, Florida. These were conducted cooperatively with the Marketing Economics Division, Economic Research Service as were similar surveys reported previously.



A food consumption survey was carried out in the District of Columbia that will provide information on the diets of households and of individuals. The study was undertaken primarily as a pilot survey in developing procedures for the next Nationwide survey proposed in the Department's long-range program.

The nutrient content of the per capita food supply is calculated and published each year, using data on estimated quantities of foods consumed (retail-weight basis) as developed by the Economic Research Service. This series, with estimates extending back to 1909, is the only source of data on year-to-year changes in the nutrient content of the U. S. per capita food consumption.

2. Food management practices. The results from three small studies based on records kept by the homemaker on the kind, amount, and nutritive value of foods used and discarded in households have been prepared as a journal article. In terms of total calories available for consumption, discarded edible food averaged 7 percent in St. Paul, Minnesota; 8 percent in DeKalb County, Missouri; and 10 percent in Los Angeles, California. A study using "recall questions," instead of records, with a random sample of 300 households in Minneapolis-St. Paul in the winter of 1960 is currently being processed.

A report on household practices in handling and storing commercially frozen foods, based on surveys in two cities has been published. Survey findings indicate that household practices alone would not cause serious quality deterioration of frozen foods.

A new study has been initiated (under contract) of the management practices of urban and farm home freezer owners in Fort Wayne, Indiana and a nearby rural area. The survey is designed to obtain information on such actual management practices of home freezer owners as the kinds, amounts, sources, prices, and rate of turnover of foods frozen and stored in the home.

3. Development of food budgets and other basic data for food and nutrition programs. The ongoing program of interpretation and application of nutrition research findings to practical problems for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education or nutrition policies has involved the preparation or review of articles and publications, talks, television interviews, and participation in various conferences and committees.

With the publication of the report "Family Food Plans and Food Costs" the technical work on the development of the Department's current low-cost, moderate-cost and liberal food plans was completed. The continuing phases of the work on individual and household food budgets consists in the regular pricing of the food plans for publication in Family Economics Review, and in dissemination of information concerning them through such popular publications as "Family Food Budgeting for Good Meals and Good Nutrition, " through

filmstrips ("Food for the Young Couple"), and through correspondence, talks and committees (such as the Advisory Committee to the Bureau of Labor Statistics on their City Workers' Standard Budget).

Progress on the revision of Handbook No. 16, "Planning Food for Institutions" has focused primarily on the food purchasing guide section. Publications in preparation that are designed for the use of teachers, extension workers and other leaders are (1) a semi-popular publication on nutrition in the series Facts for Nutrition Programs; (2) a report on fat and related components in U. S. diets; and (3) a study of the relative economy of foods.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides one channel for disseminating pertinent information and for reporting nutrition education activities. Examples of subjects of current interest covered during the report period are: "Nutrition Aspects of Selected Studies of Cardiovascular Diseases--Implications for Nutrition Education," "Planning Nutrition Programs for Elementary School Teachers," and "Food Guides--A Teaching Tool in Nutrition Education."

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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## III. MARKETING AND ECONOMIC RESEARCH

SWINE - MARKETING FACILITIES, EQUIPMENT AND METHODS  
Transportation and Facilities Research Division, AMS

Problem. Many of the livestock, meat, and wool marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motor-truck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities needed - such as livestock auction markets, commercial feedlots, and hotel supply houses. Most private firms handling livestock, meat, and wool lack the technological and engineering skills necessary to plan and develop suitable facility layouts and designs and to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency; including the designing of improved plant layouts, which will provide proper arrangement of work areas to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used in many plants.

## USDA PROGRAM

The Department has a continuing long-term marketing research program involving industrial engineers, agricultural economists, and meat scientists engaged in both basic and applied research to develop new and improved methods, equipment, processes, and facilities for livestock markets, meat packers and wholesalers, and wool warehousemen. Livestock market research is carried on at Washington, D. C. Part of the work in this area is being done either under contract or in cooperation with the Toledo Scale Corporation, Toledo, Ohio, and the Central Missouri Livestock Auction, Mexico, Mo. Work on the behavioral patterns of livestock is under a contract with the American Research and Mfg. Corp., Rockville, Md. The research on livestock slaughtering and on meat packing and wholesaling at Stillwater, Okla., is cooperative with the Oklahoma Agricultural Experiment Station. Wool warehouse research is carried on at Washington, D. C.

The Federal effort devoted to research in this area totals 6.3 professional man-years; 3.1 man-years (including 2.1 man-years of contract work) on livestock marketing, 2.3 man-years on meat facilities, 0.2 man-year on wool warehouses, and 0.7 man-year on program leadership.

## REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Automation of Sales Operations on Livestock Markets

At the Central Missouri Livestock Auction Market, Mexico, Mo., the combination electronic load-cell and lever-system scale, and the scoreboard for flashing gross weight, average weight, and price to the audience continues to perform well. The manual-key input device for transmitting sales information from the auctioneer's box to the office and the computer for receiving sales information, making the necessary calculations, and preparing the seller's check have not proven satisfactory. The time required by the computing and recording systems tested results in a delay of the auction sale. To eliminate the delay, this equipment must perform its function in about 20 seconds per sale or transaction instead of the 35 seconds now required. At the end of the year equipment modifications were being made to speed up the cycle.

As previously reported, the electrically-operated pen gates; developed under a research contract with Milro Controls Company and installed on the Mexico, Mo., market; failed to function with the degree of satisfaction desired. Although the gates opened and closed at the proper speed and stopped when coming in contact with animals without injuring them, when once stopped by animals during the opening and closing cycle the gate could not again attain the desired speed for opening or closing promptly. A new contract was negotiated with the Toledo Scale Corporation during the year to determine the physical and economic feasibility of developing electrically-operated gates. The contractor's report is due on or before April 1, 1964.

B. Determining Behavioral Patterns of Livestock

A contract with the American Research and Manufacturing Corp., Rockville, Md., was negotiated for developing design criteria for an automatic driving device for livestock markets. This research will involve observations and experiments to establish the behavioral patterns of cattle, hogs, and sheep under environmental conditions existing on stockyards and auction markets when handled or driven both singly and in groups ranging up to 10 animals and when they are subjected to:

1. Light rays of different candlepower, intensity, and bands of the spectrum.
2. Sounds of different pitch and intensity.
3. Air blasts of different velocities and temperatures.
4. Electricity applied at different voltages and by various means.

A mechanical "sweep" or "driver," of alley or sales ring width, equipped with selected devices, including rubber fingers, for prodding animals also will be tested.



At the end of the year work on this project had not progressed to the point that significant results were available.

C. Developing a Physically Integrated Livestock Marketing and Slaughtering Facility

Work on this project had not progressed to the point that significant results were available at the end of the year.

D. Layouts and Work Methods for Hotel Supply Houses

At Stillwater, Okla., a draft of a report entitled "Hotel and Restaurant Meat Purveyors - Custom Service Houses - Improved Methods and Facilities" was tentatively completed and reviewed by operators of custom service houses prior to its submission for clearance for publication. The reviewers made a number of recommendations which should make the report of more value to and more easily understood by the operators of hotel supply houses. At the end of the year the report was being revised to include their suggestions. Progress on a similar study of frozen portion control hotel supply houses includes the tabulation of all field data and the determination of the composition of products to be fabricated by a house handling an assumed annual volume of 3,900,000 pounds.

E. Layouts and Work Methods for Hog Slaughtering Plants

The Stillwater, Okla., office, in cooperation with the Oklahoma Agricultural Experiment Station, conducted field studies in hog slaughtering plants located in South Carolina, Alabama, Mississippi, Missouri, Kansas, Ohio, Indiana and Texas. Partial analysis of these data have been made; however the work has not progressed to the point that significant results can be summarized.

F. Handling and Processing "Hot" Pork Products

At Stillwater, Okla., a project was initiated in cooperation with the Oklahoma Agricultural Experiment Station, to determine the feasibility of and develop methods and techniques for: (1) Fabricating pork carcasses prior to chilling, (2) curing and smoking trimmed boneless cuts prior to/or during quick chilling, and (3) boning and trimming "hot" cuts prior to chilling. The ultimate objective of the study when the above feasibility studies are determined is to obtain data to be used for methods, equipment and facility designs for the commercial processing of "hot" cut pork products. Most equipment, supplies and materials for the feasibility studies have been purchased and background and biographical data compiled for getting the study underway. At the end of the year Oklahoma Station staff members, who will conduct the research under a Cooperative Agreement, were in the process of setting up research methods and techniques to be used during the first year's study. As far as can be determined from the biographical study, no U. S. concern has used or is now employing the processing techniques proposed for study under this project.

## COOPERATIVE MARKETING

### Farmer Cooperative Service

Problem: Farmers continue to expand their use of cooperatives in marketing the products of their farms. In light of the rapid and complex changes taking place in technology and in market organization and practices, research is needed to help farmer cooperatives and other marketing agencies perform needed marketing services both more efficiently and more effectively. Farmer-directors, managers and others, including the public, need more information to assist in making decisions on how cooperatives can maintain and strengthen the bargaining power of farmers, increase efficiency and reduce costs of marketing, and better meet the needs of our mass distribution system for large quantities of products on a specification basis.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting farmers' marketing problems in our modern, dynamic system. They are organized and operated to increase farmers' net income. However, cooperatives face many problems in achieving this goal. Cooperatives must find ways to consolidate volume, for example, through internal growth, merger, acquisition or federation, to strengthen their market position and meet the needs of mass merchandising. Ways must be found to reduce costs by increasing efficiency through improved operating methods, better organization and management, and more use of new technologies.

### USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State Experiment Stations, Extension Services, and Departments of Agriculture.

The number of Federal professional man-years devoted to research in this area totals 21.2, of which 1.0 man-years are on the cooperative marketing of citrus, 2.7 to cotton, 3.5 to dairy, 1.0 to deciduous fruit, 0.2 to forestry, 1.9 to grain, 2.6 to livestock, 1.3 to oilseeds and peanuts, 1.0 to potatoes, 2.7 to poultry, 0.2 to rice, 1.0 to sheep and wool, 0.1 to sugar, 1.0 to tobacco, and 1.0 to vegetables.



Research also is conducted under contract with land-grant colleges, universities, cooperatives and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Carolina, North Dakota and Oregon, and by two private research companies.

In addition, 15 case studies of individual or groups of cooperatives were completed. These were concerned with the improvement of operating methods and the feasibility of coordinating the marketing of two or more cooperatives.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### Livestock

1. Pooling and pricing. Additional findings from a study on the efficiency of pooled sales were published in three reports covering feeder cattle, feeder pig, and veal calf pooling operations. Work is continuing on preparation of reports on lamb and slaughter hog pooling operations.

The veal calf publication reported an estimated 154 market agencies in 10 States were pooling calves. They pooled an estimated 668,000 calves in 1959, over 97 percent of which were in Kentucky, Ohio, Tennessee, Virginia, and West Virginia. Other areas of the country seem particularly well suited to the use of pooling, especially the heavy dairying sections. Market agencies estimated that producers received from \$1 to \$2 a hundredweight more for calves that were pooled than they would have received had the calves been sold singly. In addition to this benefit to producers, it was estimated that market agencies saved an average of 48 minutes a sale by selling calves in pooled lots. Assuming an hourly operating cost of \$50, these agencies would have saved an average of \$40 a sale, or over \$2,000 a year. This means a total savings of nearly \$300,000 annually for all agencies engaged in pooling.

Work was completed on a study which showed that, while cooperatives are using USDA grades and paying price differentials for hogs only to a limited extent, these practices appear to be increasing. The study indicated the need for encouraging greater use of grades and price differentials to increase quality production.

2. Livestock integration. More and more cooperatives are looking for ways to integrate their operations to help farmers maintain control over their products further in marketing channels and to become a more effective bargaining force in the marketing of livestock. Integration is taking the form of expanded contract production and marketing pro-

grams and the operation of livestock feedlots and slaughtering and meat processing facilities. Work continues on a study of methods that cooperatives and livestock producer groups can use to successfully integrate their operations.

Three ARA technical assistance studies were initiated to determine the economic feasibility of establishing cooperative livestock feedyards and slaughter facilities in North Dakota, Montana and Oregon. In these studies, being done under contract with the land-grant colleges in these States, four main factors are considered: Supply of livestock, supply of surplus feed grains, kind of markets available, and availability of competent management and labor. Preliminary manuscripts have been prepared by the contractors on those portions of the studies completed to date. Findings from the studies in these three States will be of value to cooperatives and producer groups in other States having similar characteristics when analyzing the feasibility of integrating their operations.

Studies were made on the feasibility of lamb slaughtering plants in the Pacific Northwest and the Middle Atlantic States, and beef plants in the western area.

3. Improved market procedures in the Northeast. Work is continuing with the Northeastern States through a new project that seeks to determine the market potential for live animals produced in the Midwest, as well as for beef and hog carcasses and fresh pork cuts now slaughtered and cut in midwestern plants. All type of plants and market outlets will be studied.

4. Coordination of marketing. Previous study on the possible advantages of consolidating the operations of cooperatives in California is being continued with analysis of the feasibility of such a move by two associations.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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ECONOMICS OF MARKETING  
Marketing Economics Division, ERS

Problem: Within most agricultural processing industries rapid and drastic changes in their market organization and practices are occurring. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products. A significant aspect of the problem in marketing is that this type of information must be obtained from firms engaged in business -- in contrast with other types of research where the problem can be transferred to a laboratory, experimental plot, or other simulated situation. Consequently, it requires the cooperation of people engaged in making their living and assisting with marketing economic research on the side, where their own merchandise, facilities, and opportunity for profit and loss to themselves is involved. Another aspect of the problem is that only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

USDA PROGRAM

The Department has a continuing program to determine the reason for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. Because more than 50% of the consumer's dollar spent for meat products goes for marketing activities, this work encompasses a wide range of subject matter.

It covers all economic aspects of marketing from the time the products leave the farm until they are purchased by ultimate consumers. Much marketing research is functional in nature and could apply to a number of commodities.

A. Market Potentials for New Products and Uses

This is a continuing long-term program involving agricultural economists, economists and personnel with dual economic and technical training engaged in research to bridge the gap between laboratory developments and commercial adoption so as to assist producers to realize more rapidly and more fully benefits of lowered costs, increased returns, and expanded markets that new products and new uses can afford. Research is carried on in indus-

trial and food uses at Washington, D.C., and five field offices -- agricultural economists are located at each of the four Utilization Research and Development Divisions - New Orleans, La.; Albany, Calif.; Philadelphia, Pa.; and Peoria, Ill.; and at the Hawaii Agricultural Experiment Station, Honolulu, Hawaii. Of the Federal effort involving 20.5 professional man-years, 4.2 are devoted to animal products.

#### B. Merchandising and Promotion

The Department has a continuing long-term program of research in merchandising, management analysis, product distribution, and promotion evaluation, designed to provide useful information to producers, handlers, and distributors by which markets for farm products can be maintained and strengthened.

Merchandising research is conducted to quantitatively measure the impact of selected selling practices and pricing policies on sales of and demand for agricultural products. Research in this area is concerned with specific studies such as: Development of income-expenditure elasticities for selected products; identification of consumer and market profiles; and evaluation of alternative package sizes, displays, pricing techniques, and quality of products on consumer purchases. Along with the merchandising research is a relatively small undertaking involving management type studies designed to improve the efficiency of firms distributing farm products with work at the assembly and wholesale level being emphasized.

Research appraising and analyzing promotional programs of agricultural groups is directed toward studies such as: Organizational structure and procedures of commodity groups for optimum control, coordination, and effective conduct of program; measurement of levels of advertising and promotional intensity necessary to maximize sales; and evaluation of effectiveness of alternative appeals, themes, and techniques in selling farm products.

Of the Federal effort involving 17.6 professional man-years, 0.7 are devoted to cross-commodity animal products.

#### C. Marketing Costs, Margins, and Efficiency

The Department has a continuing long-term program of research in marketing margins, costs, and efficiency designed primarily to provide useful information on the amounts and trends in marketing margins, costs of marketing, labor and equipment requirements, cost standards, economies of scale, and other factors including marketing practices, affecting costs of marketing through all important trade channels and types of firms and for all farm products marketed in commercial volumes. Most of the research is problem-solving in nature, and is conducted by professional agricultural economists. Some studies are conducted in close cooperation with agricultural engineers



and members of other disciplines. In nearly all studies close cooperation is maintained with industry and trade groups and with private firms that generously provide essential data and make plant facilities available for observation and the conduct of various market tests. Although most of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located at field stations in several States. These agricultural economists work closely with State agricultural experiment stations which also **share** a part of the expense of the cooperative studies.

Of the Federal effort involving 42.2 professional man-years, including cooperative agents paid mainly from Federal funds, 5.8 are devoted to livestock products.

#### D. Market Structure, Practices, and Competition

The Department has a continuing long-term program of economic research to assist farmers and marketing agencies to adapt to changes in market structure, practices and competition. Work in this area is conducted at Washington, D. C., at field offices in Berkeley, California and Denver, Colorado, at 20 experiment stations under cooperative agreements or contracts, and by a private firm under contract. The Federal scientific effort devoted to economic research in this area totals 42.4 professional man-years of which 1.7 is devoted to beef cattle, 4.1 to livestock, and 0.1 to hides.

#### E. Economics of Product Quality

The Department's program of basic and applied research on the economics of product quality includes study of the problems of seven different commodity groups. Work on all commodities is carried on in Washington.

Of the Federal effort involving 14.3 professional man-years, 0.9 are devoted to swine.

#### F. Information, Outlook, and Rural Development

The Department's research program concerning marketing information, outlook, and rural development includes situation and outlook reports concerning prices, costs and margins, employment, marketing services, market structure, means of collecting and disseminating market information, and feasibility of investments in rural areas.

The Department's continuing program of economic research relating to marketing information, outlook, and marketing aspects of rural development is conducted mainly at Washington, D.C.; work on marketing information is conducted at Baton Rouge, Louisiana, Manhattan, Kansas, Columbia, Missouri, Madison, Wisconsin, and University Park, New Mexico; and work on long-term outlook at Berkeley, California, and Corvallis, Oregon.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Market Potentials for New Products and UsesLeather

Synthetics have been substituted for leather in a number of uses. Market research to appraise the probable extent of this competition and means by which leather may better serve market requirements reveals that leather stands at the crossroads. Shoes, luggage, handbags, and a number of other products, once made chiefly from leather are being made in increasing quantities from non-leather material. Leather is striking back through technological improvements aimed at lowering cost and improving quality. Developments to date have been helpful, such as glutaraldehyde tanning and brine curing but leather's hope lies in the achievement through research of major technological gains.

B. Merchandising and PromotionEconomics of Pricing, Merchandising, and Labor Utilization in Retailing Meat and Meat Products

This work is being carried out in cooperation with the Ohio State Experiment Station in a sample of retail food stores. A preliminary analysis of data on labor utilization indicated potential savings from more effective planning and coordination of feature promotions, advertising and merchandising and the use of commodity time requirement data for scheduling and utilizing meat department employees. The impact of features appeared to vary both by type of feature and among stores with the magnitude of the sales variation depending upon the class-of-trade. Preliminary analysis of labor utilization data indicated that at least 90 percent of the variance in man-hours spent processing wholesale cuts into retail cuts is explained by tonnage volume indicating no significant economy of scale. These data along with other data to be collected will be used to develop and test improved managerial techniques that will reduce marketing costs and increase sales of meat products.

C. Marketing Costs, Margins and EfficiencyLivestock

1. Marketing Costs and Margins. A study of accounting records from large independent meatpackers showed about 7 percent of the average retail price of fresh beef went to cover costs to packers for slaughter, shipping and delivery services, compared with farmers' share at about 60 percent.



Allocation of these costs to labor, grading royalties and packaging, procurement and selling transportation and delivery were similar in amount and proportion in January-March 1963, October-December 1962, and the average for January-December 1961.

Retail meat prices appear to adjust to changes in prices of live animals only after lag of five to eight weeks. This lag was observed in the most recent drop in beef prices and appears to be of about the same magnitude as in similar circumstances in past years.

2. Costs of Slaughter. Summary of data from monthly accounting records for 1962-63 for large independent packers showed labor cost about \$1.50 per 100 lbs. of dressed beef; over one-third of packers' total processing costs of \$4.20 per 100 lbs. Shipping and delivery costs amounted to about \$1.05 per 100 lbs. and fixed overhead to another \$1.00. Local delivery and cost for procurement and selling averaged about \$ .35 to .40 per 100 lbs.; transportation to distribution centers about \$ .75 per 100 lbs.; packaging, grading and royalties about \$ .20 per 100 lbs. Three-fourths of the packers reported costs for grading and royalties.

About two-thirds of labor cost was for slaughter operations, head and offal workup, and the chill cooler; about one-fourth for shipping cooler labor in loading out; and the remainder for hide-cellar operations.

No consistent cost differences could be attributed to size or location of plant, for this sample, but there was a wide range in costs for plants of similar size.

4. Structure of Livestock Slaughter. Livestock slaughter has become less concentrated in the hands of the 4 and 8 largest firms. This is true for all species and for amalgamated livestock slaughter. Slaughter plants have also become more specialized. Plant and firm entry and exit vary considerably from year to year, but in each of the past 12 years new capacity has been greater than the capacity withdrawn.

5. Pricing Livestock. Annual and semi-annual econometric models of price determination in the beef and pork sectors have been developed and tested. Projections have been made to 1960-1975. Beef production has been disaggregated into fed, nonfed, and dairy components. Interregional least cost of transportation flows for 1955 and 1965 for feeder and slaughter cattle.

The daily pricing process of packer buyers and commission firms have been observed at Denison, Iowa, and East St. Louis. Representatives of meat-packing firms have been interviewed regarding daily pricing operations. A panel of 80 livestock producers have been contacted.

## Hides, Skins and Leather

Supply and Demand for Leather and Substitutes. The prospective supply of hides resulting from increasing rates of slaughter of domestic livestock will require greatly expanded domestic and foreign markets for hides, leather, and leather goods. Unfortunately, for the hide and leather industries, and indirectly for livestock producers, leather and leather products are experiencing increasingly severe competition from substitute products. If present trends continue, 60 percent of U. S. shoe production may be made of non-leather materials by 1970. Also, by this year, with a decreasing domestic demand for leather, perhaps as much as half of our total hide supply estimated at 34 million hides may have to move into foreign outlets. A major technological breakthrough in tanning appears to offer the greatest promise for making leather more competitive, pricewise, with substitute products. Reducing the costs of curing hides may help some. The value of hides and skins at the packer level is estimated to be about 4 percent of the retail value of leather goods.

### D. Market Structure, Practices and Competition

#### Livestock

1. Wholesale Marketing Channels. Marketing channels for wholesale meat distribution in the United States have been described and changes in the structure in the wholesale market evaluated on the basis of data from the Census of Manufactures. The decline in the importance of packer branch houses observed since the 1920's appears to be continuing at the same time independent meat wholesalers are becoming more important in the wholesale channels for meats.
2. Specification Buying of Meat. Of 1375 chainstore and independent retailers interviewed in Maryland, West Virginia and New Jersey, only 7 reported use of contracts with farmers or livestock feeders. About one-half of the retailers reported specifying grade, Federal or State inspection and sex when purchasing meat; nearly all specified weight range and cut, delivery date, price or pricing basis and method of payment.
3. Structure of Texas-Oklahoma Livestock Economy. Except at retail, not many changes in the structure of the Texas-Oklahoma meat industry are evident. However, substantial changes will be required in the near future. Sharp changes in meat retailing and wholesaling have caused changes in procurement practices. Fed livestock are increasingly in demand. As the Texas-Oklahoma livestock-meat economy moves to accommodate the changes in livestock feeding and slaughtering, the number of slaughtering firms will continue to increase, and plants will be larger in size. Fewer wholesaling firms will be required, but those remaining will be larger.



A break-even analysis of changing beef volume showed both that with varying buying prices and selling prices and with costs that vary with changing volume in varying patterns, most packers find that the volume range for profitable operations is narrow and income barely covers costs; attempts to increase profits expanding volume are likely to squeeze operating margins further.

Labor requirements in hog-killing operations ranged from about 1.4 head per man-hour to about 6.3 head per man-hour. Part of the variation is influenced by plant capacity. Most of the variation efficiency among plants seemed to be associated with physical factors such as varying equipment-labor combinations.

3. Livestock and Meat Movements in the Southeast. Apparently the movement of hogs in the Southeast is relatively efficient. The hog-pork industry can compete favorably with the Midwest under the current transfer cost structure. However, if hog slaughter costs in the Southeast increase to the level of slaughter in the Midwest, it will be more economical to ship pork to the Southeast than to ship hogs in for slaughter. In this case, the Southeast hog slaughtering industry will be more dependent upon local hog production.

4. Costs of Curing Hides. The completed analysis of several hide curing methods indicates that the volume of hides cured in a plant is important in choosing the most efficient method of curing. Pack-salt curing is the lowest-cost method for plants processing fewer than 300 hides a day. The agitated-brine method is slightly more efficient at daily volumes of 300-500 hides, and for larger firms the agitated-brine method definitely is the least costly method. The costs of fleshing were estimated at 16 cents per hide with a volume of 400 hides daily, but only 12½ cents with a volume of 1,000 hides a day.

#### E. Economics of Product Quality

1. Grades for Hogs. Current standards for barrow and gilt carcasses are quite good. Some of the modifications that are often suggested would not improve the standards which rely on backfat thickness and weight or length. These factors are good indicators of percent lean cuts, and percent lean cuts, given weight or length, is very closely associated with value. Paying price differences can be evaluated on the basis of value differences between grades computed under different price and grade distribution.

2. Grade Composition of Market Hogs. Of barrow and gilt carcasses, 33 percent graded No. 1; 39 percent graded No. 2; 26 percent graded No. 3; 2 percent graded medium; and less than 1/2 percent graded cull.

Other results of the study include distribution of barrow and gilt carcass length and backfat thickness by grade and distribution for sows.

## F. Information, Outlook, and Rural Development

### Leather and Competitive Substitutes, Long-term Trends in their Supply and Demand

Present trends indicate that 60% of the domestic shoe production may use nonleather materials by 1970. With such a decrease in domestic demand for leather, half of our total hide supply, estimated at 33 to 35 million hides, may move into foreign markets by 1970.

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ECONOMIC AND STATISTICAL ANALYSIS  
Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

USDA PROGRAM

The program of basic research into the factors affecting prices, supply, and consumption of principal agricultural commodities has emphasized four broad research areas: (1) measurement of consumer response to price; (2) measurement of the effect of price and other factors on the production and supply of farm products; (3) measurement of the effect of supply and demand factors on farm prices and prices to consumers; and (4) improvement of statistical techniques for measuring economic relationships.

Changes in emphasis are made from time to time to utilize effectively the professional skills available and to adjust to work having the highest priority. The current emphasis is on a comprehensive analysis of the price-making forces in the feed-livestock economy, especially on factors affecting supply. As specific agricultural programs are usually proposed on a commodity basis, the current program is discussed in detail on a commodity basis though much of the actual research is carried on jointly for related commodity groups.

Livestock and Meat. This work involves 1.5 professional man-years located in Washington, D.C. Research on livestock is part of a comprehensive analysis of the price-making forces in the feed-livestock economy. This study gives special attention to the quantitative measures that show what happens to the production of each commodity within the feed-livestock sector following changes in price of one or more of the commodities. The study includes analyses for the United States as a whole and for regions to measure differences in price response and to allow for the important farm and non-farm alternatives available in each region. The present emphasis is on economic factors that affect the supply and price of beef cattle and the demand for feeder cattle and the interrelations among these factors. Results from the beef, hog and feed grain studies along with analyses for milk, eggs, and broilers will be incorporated into an overall analysis of the feed-livestock economy.



The program pertaining to commodity situation and outlook analysis includes the regular publication of 11 commodity outlook reports; holding of the Annual Outlook Conference in Washington in mid-November; participation of commodity specialists at regional or State outlook meetings or at meetings of farm organizations and agricultural industry groups; preparation and publication of special articles bearing on both the short-run and long-run outlook for farm commodities; issuance of comprehensive statistical bulletins containing the principal economic series pertaining to the various commodities; long-range projections of supply of and demand for the major agricultural commodities; and continuing analysis of the impact of existing and proposed alternative farm programs as they affect output, utilization and prices of these commodities.

The total commodity situation and outlook program currently involves 22 professional man-years.

(a) Livestock and Meat. This work involves 2.5 professional man-years in Washington and 2.0 professional man-years in Denver, Colorado. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of livestock and meats. These appraisals, developments of interest to the industry, and results of special studies are published 7 times a year in regular issues of the Livestock and Meat Situation, in special additional issues as warranted, quarterly in the Demand and Price Situation and the National Food Situation, and monthly in the Farm Index. A comprehensive analysis of the livestock situation is presented at the Annual Outlook Conference. Outlook appraisals are frequently presented at regional or State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply and consumption of livestock and livestock products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Livestock and Meat Statistics is published annually.

A Western Regional Field Office in Denver, Colorado, conducts a continuing appraisal of the conditions important to the range livestock industry of the West. The results of this activity are published monthly in the Western Livestock Round-Up, and supplemented by special releases and special materials circulated to the Extension Marketing Specialists of the Western Region.

(b) Fats and Oils. This work involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals, developments of interest to the industry, and results of special studies are published 5 times a year in the Fats and Oils Situation, quarterly in the Demand and Price

Situation and the National Food Situation, and monthly in the Farm Index. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference, and more limited appraisals given at meetings with industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply, and consumption of fats and oils and their products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Oilseeds, Fats and Oils, and Their Products, is being revised for publication in 1964.

Increasing emphasis has been on the effect of increased fat output and export markets on prices and incomes received by farmers.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Supply, Demand and Price Analysis

Work on demand for meats included an analysis of the experience in consumption of livestock and livestock products during the last decade as to clues for underlying trends that reflected changes in tastes and preferences. The analysis showed that the demand for beef and broilers shows the most promise in the postwar period. It was found that after allowing for the effects of changes in relative prices and for changes in consumer income, the net increase in per capita demand for beef and broilers was about 1 percent per year. On the other hand the trend in per capita demand for pork, exclusive of changes arising from price and income changes, was downward at a rate of 1 percent per year.

A technical bulletin was issued in December 1962 which describes the major economic relationships that affect the supply and price of hogs. This bulletin won first prize in the American Farm Economic Association Awards for published research competition. The bulletin contains an explanation of the factors involved in the cyclical behavior of production and prices of hogs, and measures the effect of various factors such as the prices of feed, beef and poultry, and consumer income on the hog economy. Results of this study were reported in detail in last year's report.

Work on price and supply of beef cattle during the current reporting period was centered on an analysis of economic factors that influence the inventory accumulation and depletion of beef cattle. The inventory of beef cattle is depicted as being made up of the number of (1) beef cows on farms (2) beef cattle on farms 1 to 2 years old (3) beef calves on farms and (4) beef bulls on farms. Supply and demand relations are being formulated for each



component part and preliminary statistical results have been obtained for some of the relationships. Research during the year has been mostly on items (1) and (2). The demand for beef cows for slaughter has been related to (1) price of utility slaughter cows, (2) price of heifers and (3) price of slaughter hogs. The supply of beef cows for slaughter has been related to (1) price of utility slaughter cows, (2) price of slaughter calves, (3) number of beef heifers brought into beef herd, and (4) range conditions. The demand for heifers to be brought into herd was related to (1) price of heifers, (2) the number of beef cows slaughtered, and (3) price of calves. On the other hand the supply of heifers to be brought into beef herds was depicted as depending on (1) price of heifers, (2) beef-corn ratio, and (3) the number of calves on farms the previous year.

As part of the cattle study, regional locational patterns of different classes of cattle have been made. The individual regional influences of the changing location patterns are being traced and related to the United States as a whole.

## B. Situation and Outlook Analysis

The increase in beef production this year exceeded the increase in demand, and fed cattle prices fell. While part of this drop in the opening months of 1963 was recovered by mid-year, prices of fed cattle remained well under 1962 levels for the second half of the year. Continued large production is expected to cause some further weakening of cattle prices in the first half of 1964. Pork production also increased in 1963 and pork prices averaged lower than a year earlier. Pork supplies in 1964 likely will be much the same as in 1963 and prices are expected to average slightly higher, especially during the winter and early spring months. Liquidation of sheep and lambs, which began in 1960, continued the past year although the rate slowed somewhat. Lamb prices in the first quarter of 1963 were much higher than a year earlier, but in the remainder of the year averaged about the same as those in 1962. Lamb and mutton production in 1964 is expected to be only a little smaller than a year earlier and 1964 may mark the low point in the present downswing. Prices may be about the same as in 1963.

A special situation report on livestock was released in April to help producers, marketers, and consumers to understand and adjust to changes in the economic situation brought about by the sharp decline in fed cattle and hog prices. It presented basic information on the prevailing fed cattle and barrow and gilt price situation and discussed factors that were likely to influence the future.

To gauge the probable future trend in consumption, special analyses were made of the uptrend in beef and the downtrend in pork in the last decade. Emphasis was also given to study of the cattle cycle which began its current upswing in 1959. Long-run projections (5 years) were developed for cattle, hogs, and lambs as part of a set of ERS projections for the farm economy as a whole. Work on seasonal patterns of prices and production for various classes and grades of livestock and livestock products was continued. Other work in progress includes an analysis of the regional distribution of livestock production.

Livestock and Meat Statistics, Statistical Bulletin No. 333, the first master issue since the original comprehensive Statistical Bulletin No. 230, was released in July 1963.

### C. Fats and Oils

Supplies of food fats and oils during the 1962-63 marketing year were a record 16.4 billion pounds (in terms of oil), about 4 percent greater than the year before. Total disappearance rose about 5 percent to a new high, with record exports accounting for most of the increase. The Food for Peace Program again was an important factor in exports. Carry-over stocks of food fats on October 1, 1963 were down slightly from a year earlier, due to a big reduction in soybeans. Stocks of edible vegetable oils, lard and butter were up. Prices received by farmers for 1962 crops of soybeans and cottonseed remained somewhat above CCC support rates whereas flaxseed and peanut prices rested on support. Wholesale prices of all fats and oils during 1962-63 averaged slightly below year earlier levels but oilseed meal prices were somewhat higher. Most significant development during the year was the strong demand for soybean meal, which far outstripped the demand for soybean oil. The large crush of soybeans resulted in record carryover stocks of about 1.0 billion pounds of soybean oil (crude and refined) on October 1, 1963. Thus, the 1963-64 marketing year started with very large stocks of soybean oil and low stocks of soybean meal. As a result, soybean oil prices were low in relation to prices of both soybeans and soybean meal.

In addition to the regular analytic work and outlook analyses, considerable effort was devoted to improving statistical techniques used in forecasting and the development of new statistical series. Work got underway on a comprehensive statistical bulletin for fats, oils, oilseeds and their products. This handbook is badly needed by commodity analysts, as it has been 10 years since the issuance of the last comprehensive compilation of data. Greater attention is being given to some of the minor oilseed crops and our expanding foreign markets. Long-run projections (5 years) were developed for the major oilseeds, fats and oils as part of an overall set of ERS projections for the farm economy.



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